Volume 6 March 1960 No. 3

629
629.305
11

THE JOHN CRERAR LIBRARY
JAN 22 1964

Canadian Aeronautical Journal

CONTENTS

EDITORIAL: CANADA'S PARTICIPATION	*Dr. D. C. Rose*	79
DEFENCE RESEARCH BOARD'S SATELLITE		80
THE SCIENTIFIC EXPLORATION OF SPACE	*G. D. Watson*	81
A PRELIMINARY ANALYSIS OF THE PENALTIES ASSOCIATED WITH PIERCING A WING TORSION BOX WITH A GRID OF HOLES	*A. H. Hall*	90
PRECIPITATION PHYSICS RESEARCH IN EASTERN CANADA	*A. D. Wood*	95
PARACHUTES AND THEIR GROWTH	*C. Bonn*	98
INTERNATIONAL CONFERENCES		104
C.A.I. LOG Secretary's Letter, Branches, Coming Events, Members, Books		105

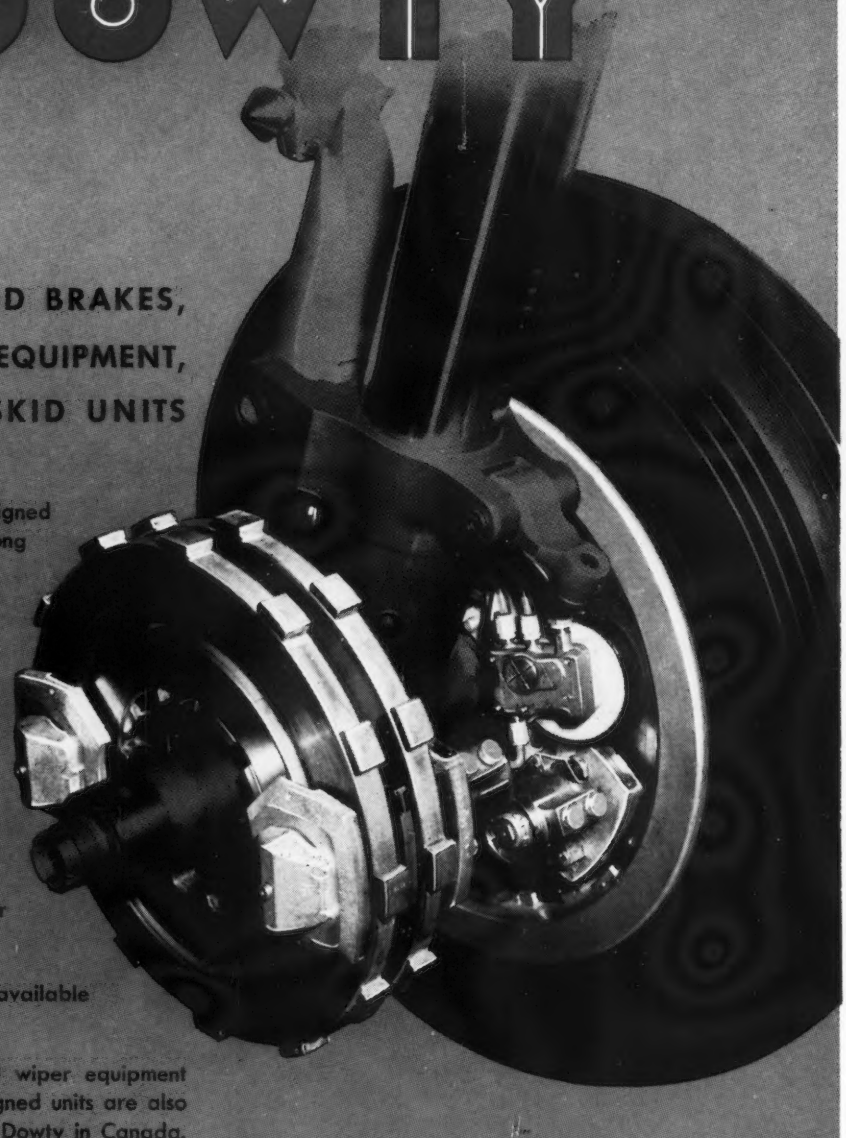
Published by the
CANADIAN AERONAUTICAL INSTITUTE
Commonwealth Building, 77 Metcalfe Street
OTTAWA

FIRST IN HYDRAULICS IN CANADA

DOWTY

DUNLOP

WHEELS AND BRAKES,
BRAKE CONTROL EQUIPMENT,
MAXARET ANTI-SKID UNITS



Simple in construction — designed for maximum efficiency and long life.

Proven in service — Dunlop units are fitted to Comet, Viscount, Vanguard, Britannia, Argus, CL44, CF100, Friendship and many other civil and military aircraft.

Manufactured, distributed and serviced by Dowty Equipment of Canada Limited under licence from Dunlop.

Dowty and Dunlop service is available throughout the world.

Dunlop MAXIVUE windshield wiper equipment and many other Dunlop designed units are also distributed and serviced by Dowty in Canada.

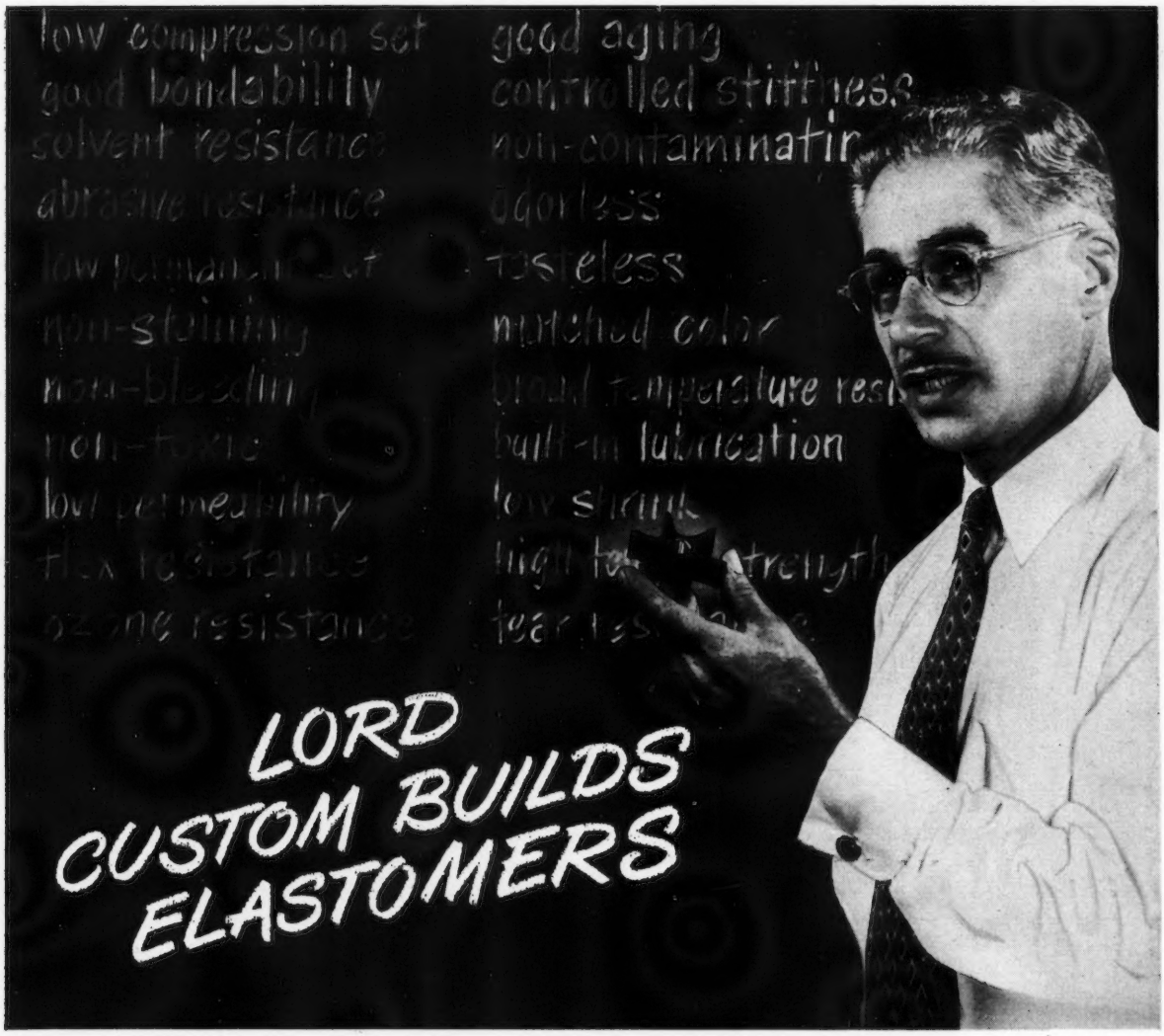
Write for our brochure 'HYDRAULICS FOR THE FUTURE'

Illustration shows CF100 Main wheel, brake and Maxaret installation.

EXPERIENCE • SPECIALIZATION • SERVICE

DOWTY EQUIPMENT OF CANADA LTD.

AJAX MEMBER OF THE DOWTY GROUP **ONTARIO**



. . . to make your design ideas work

Does your new product design require an elastomeric material with special characteristics?

LORD can assist you by developing and manufacturing custom elastomeric parts—molded and bonded—to meet the most rigid specifications. Various combinations of the above properties can be incorporated to satisfy unusual designs, special configurations, severe operating conditions.

LORD capabilities include thorough knowledge of all modern elastomers, special skills in creating custom formulations, complete testing and production facilities and exceptional success in solving difficult assignments. Superiority of the LORD rubber-to-metal bond is common knowledge.

For custom-built elastomers to translate your idea into a profitable new product, contact the nearest Railway & Power Sales Office.

RAILWAY & POWER
Engineering Corporation, Limited

NEW GLASGOW • QUEBEC • MONTREAL • NORANDA
NORTH BAY • OTTAWA • TORONTO • HAMILTON
WINDSOR • SAULT STE MARIE • WINNIPEG
CALGARY • EDMONTON • VANCOUVER

DRAMATIC ANSWER TO THE AIR CARGO DILEMMA

Many air carriers, striving to answer perplexing questions presented by a growing air cargo industry, are facing a basic decision: should they convert outmoded piston engine passenger equipment and put it on to air cargo routes? Should they order proposed cargo jets with 100,000 lb. payloads? Should they wait for further turbo-fan evaluation before making their air cargo plane commitments?

Canadair's Forty Four, offers a simple, practical answer to these vital questions. It is an optimum-size, all-new, all-cargo turbo-prop airplane that, in terms of productivity, is vastly superior to converted piston engine equipment, and one that offers, in comparison with the big jets, a payload capacity that is not unrealistically high for profitable operations during the 1960's. Furthermore, the Forty Four suffers little or no operating penalties due to runway limitations, and there will be no community noise problems.

The Canadair Forty Four has a productivity two to three times that of converted piston aircraft, at the same cost per airplane mile, and has a profit potential that will quickly recover any losses on disposal of piston engine aircraft now being used or contemplated for cargo usage. On the other hand, the Forty Four, with a payload capacity of 65,000 lbs. and a low break-even point, is ideally matched to the natural expansion of the cargo market, and will begin immediately to operate at profitable load factors.

The Canadair Forty Four is flying now and is in production for the three largest all-cargo carriers in the United States, and can be introduced into existing fleets early in 1961. The Canadair Forty Four can operate in and out of all airports presently used by four-engined piston-powered aircraft. For example, at such an important airport as Midway, in Chicago, with only 6400′ runways, the Forty Four can take off with 90% of its maximum payload and fly non-stop to San Francisco.

Sophisticated design features, including swing tail and integral cargo handling equipment, slash direct and indirect costs.

Step-by-step savings and economies inherent in the Canadair Forty Four, combined with its very attractive price, let precious capital dollars work for better return quicker than other "proposed" equipment.

Canadair, the specialist in air cargo, proposes the Forty Four as the answer to air cargo's biggest dilemma.

Principal Features of the Canadair Forty Four

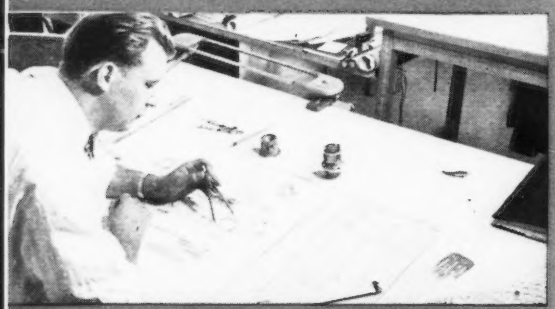
1. Low prime cost—price is less than ⅔ the price of proposed jets.
2. Low operating costs—estimated at $1.30 per aircraft mile, and less than 4¢ per ton mile.
3. Right size for the 1960's—its present payload capacity is ideally matched to forecasted requirements.
4. No community noise problems—confirmed during present flight testing.
5. No airport or runway limitations—every major airport open to the Canadair Forty Four.
6. Growth potential—able to grow with the market.
7. Available for delivery in January 1961.

CANADAIR

LIMITED, MONTREAL

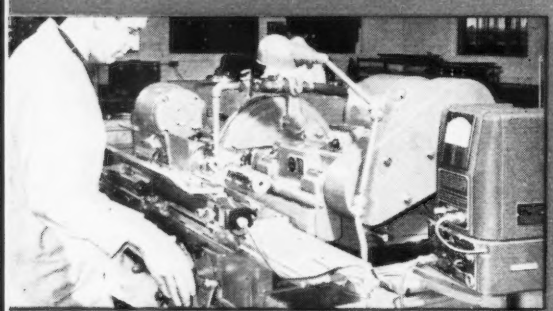
CANADAIR FORTY FOUR

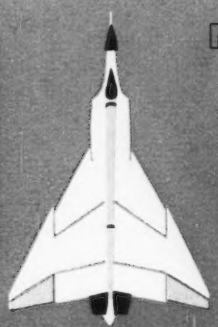
Three Faces of A·E·L



DESIGN

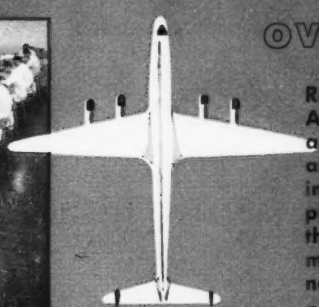
AEL's "backroom boys" form one of the finest design teams in the aviation business. A closely-integrated group of specialists have an outstanding record of designing products to meet new requirements and modifying units to fit new applications. Products are developed by environmental testing. Fully-equipped physical metallurgical and chemical laboratories having RCAF approval.





MANUFACTURING

AEL's manufacturing division contains a complete line of departments staffed by specialists and equipped with the most modern machines and test tools available. Aircraft and industrial products are fabricated, some to a tolerance of one-millionth of an inch.



OVERHAUL

Recently expanded overhaul facilities permits AEL to offer overhaul of aircraft instruments, accessories and electronic equipment with an absolute minimum turnaround time — at no increase in cost. The high standard of AEL's precision workmanship in overhaul is due to the combination of trained technicians, modern tools and test equipment and ideal new plant conditions.

For the finest in aviation design, manufacturing and overhaul — talk to AEL.

AVIATION ELECTRIC
LIMITED

200 LAURENTIEN BLVD., MONTREAL, P.Q.

BRANCH PLANT:
AVIATION ELECTRIC PACIFIC LIMITED, VANCOUVER AIRPORT, VANCOUVER, B.C.

CANADIAN AERONAUTICAL INSTITUTE

PATRON

H.R.H. The Prince Philip
Duke of Edinburgh

COUNCIL 1959-60

PRESIDENT

Dr. D. C. MacPhail

PAST PRESIDENT

Dr. G. N. Patterson

VICE-PRESIDENT

Mr. D. Boyd

COUNCILLORS

Mr. J. P. Uffen
Mr. G. F. W. McCaffrey
Dr. J. H. T. Wade
Mr. E. H. Higgins
Mr. C. M. Newhall
A/C W. P. Gouin
Mr. L. C. Bryan
Mr. G. W. T. Roper
F/L J. J. Deslauriers
Mr. J. G. Davidson
Mr. J. G. Portlock
F/O A. J. Robinson
Mr. E. K. Prentice
F/L L. S. Lumsdaine
Mr. E. C. Garrard
CDR E. B. Morris
S/L M. R. Barrett
Mr. W. E. Jamison

SECRETARY-TREASURER

Mr. H. C. Luttman

CANADIAN AERONAUTICAL JOURNAL

Publications Committee:
Mr. H. C. Oatway
Mr. J. A. Dunsby
Mr. J. J. Eden
W/C D. A. MacLulich
Editor: Mr. W. A. Chisholm

Subscription—$4.00 a year. Single copy—50 cents.

Published monthly, except in July and August.

The Institute is not responsible for statements or opinions expressed in papers or discussions printed in its publications.

All communications should be addressed to The Secretary, Canadian Aeronautical Institute, 77 Metcalfe St., Ottawa 4. Ontario, Canada.

Authorized as second class mail, Post Office Department, Ottawa

Printed by The Runge Press Ltd., Ottawa, Ontario, Canada

DEFENCE RESEARCH BOARD'S SATELLITE

A mock-up of the "top-side sounder" satellite. This satellite will weigh about 200 lb and is about 42 in in diameter. The multi-faced ring will be covered with solar cells used to power the installed electronic equipment. Long whip-like antennas will be extended after the satellite is in orbit. **(See pages 80 and 88)**

EDITORIAL

CANADA'S PARTICIPATION

About eighty years ago when polar regions in the Arctic were being explored, one of the explorer scientists in trying to organize the first International Polar Year emphasized again and again that exploration alone without precise scientific measurements of the new environment was of no value at all. The terrific appeal that space science has to the public, and its useful commercial possibilities, makes it advisable to emphasize the objective of that early explorer. The important thing is to get a more exact knowledge of the strange environment which is now becoming accessible. Getting there first or having been there is not nearly as important as the extent of knowledge gained and reported. Friendly rivalry in attaining this objective is an excellent thing and, as at present, when this reaches a point where the political and public interest is great enough in some countries to give almost unlimited financial support, scientific and technological advances occur at an unprecedented rate.

It is gradually being realized that achievement can be of value only when the scientific results are presented openly and in a way that they can be discussed and used by experts the world over. This very fact makes it possible for scientists in any country, no matter how small, to take part. For instance, a theoretical astrophysicist can make important advances in the study of perturbations in satellite orbits with no more equipment than data he may get from launching countries and some paper and pencils. A number have already done so.

Canada's position in this field is an intermediate one. We have been intimately concerned for many years with what might now be termed "nearby space", that is, a search for a better understanding of the ionosphere, the aurora and other interactions of the earth's magnetic field with the plasma surrounding the earth's atmosphere. Our geographic position in this regard is of considerable scientific importance. This is because many of the interesting upper atmosphere and nearby space effects centre around the polar area of the earth's magnetic field.

The only readily accessible areas within polar regions of magnetic activity (which have profound practical effects on communication as well as on academic scientific interest) are in Canadian territory and we have considerable responsibility in regard to scientific measurements in the Canadian north. It is quite out of the question to forbid the acquisition of scientific knowledge because of national sovereignty over such important areas. For this reason we welcomed the United States activity in setting up a rocket range at Churchill for scientific purposes during the International Geophysical Year. It is also natural that our scientists, who have long been concerned with the physics of the upper atmosphere at aurora and ionosphere heights, should take an active part in practical measurements as facilities become available either by cooperation with our neighbours or by our own efforts as our capabilities grow.

For many years there will be a gap between balloon measurements at heights up to about 30 km and the lowest practical satellite orbit of about 200 km. This is a particularly important and interesting range of altitudes in the environment of the upper atmosphere. Our contribution for the present can be largest by concentrating in this region. It is scientifically important in northern areas and a reasonable rocket program which Canada can afford can be carried out on our own as well as in cooperation with United States groups.

While this seems a good immediate objective it should not inhibit us from expanding our ideas to suggest satellite loads for United States satellite experiments in fields like the ionosphere where Canadian work has been well recognized. By developing our own program with a peaceful scientific objective and our own tools (rockets and equipment) to carry it out in our important northern areas, we not only will contribute something to the advancement of world-wide knowledge but will get some experience in this field of space technology which is quite likely to have an appreciable effect on our scientific and industrial future.

Dr. D. C. Rose
Chairman
Associate Committee on Space Research
National Research Council

DEFENCE RESEARCH BOARD'S SATELLITE

In April, 1959, the Defence Research Board and the US National Aeronautics and Space Administration announced acceptance by NASA of a proposal by the Defence Research Telecommunications Establishment for a joint satellite experiment.

Initially, DRTE proposed that instrumentation designed to investigate the top layers of the ionosphere be included in a NASA satellite conducting other experiments. Further consideration strongly suggested the advisability of employing all the space in a complete satellite for the Canadian experiment. NASA agreed to this proposal and, for economic and logistic reasons, it was decided that DRTE should construct the satellite shell as well as its instrumentation.

To be launched late in 1961 at Vandenberg Air Force Base by means of a three-stage Thor-Delta rocket provided by NASA, the experiment will be designed to achieve two objectives.

Firstly, the satellite will examine and record fundamental scientific information about the structure of upper levels of the ionosphere by using a radio sounder above the ionized layers. Secondly, it will provide information about galactic noise or the radio signals which emanate from outer space. This information is needed both by Canada and the United States as a phase of their research programs aimed at improving long distance telecommunications.

The DRB satellite, which will be launched in a near-polar orbit, will be constructed of aluminum and fibreglass, nearly round in shape and girdled by banks of solar cells. The diameter of the girdle will be about 42 in and the weight of the complete satellite will be of the order of 200 lb. (See Figure 15 on page 88.)

The experiment will require the construction of four satellites by the Ottawa establishment: one for environmental tests on the ground, another to be tested as the prototype and two at the launching site to provide a reasonable assurance of a successful experiment.

The long wavelengths used for sounding the ionosphere require long satellite antennas. The two 30 ft antennas projecting from the sides of the vehicle will be the longest used in satellites to date. The steel antennas, coiled within the vehicle during launching, will extend like a carpenter's rule when the satellite achieves its orbit.

To protect the satellite during its acceleration through the dense atmosphere, it will be enclosed in a metal nosecap or shroud. On reaching orbit altitude of 700 miles, both the nosecap and the third stage rocket will be separated from the satellite.

DRTE will operate four receiving stations in Canada. NASA will provide high-altitude sounding rockets and launching services to test the prototype payload and will also be responsible for ground receiving stations outside Canada. It is hoped that the satellite will continue to transmit data for about a year following the launching. The information obtained will be exchanged freely with other nations through the Committee on Space Research of the International Council of Scientific Unions.

The DRTE scientists are assessing carefully the characteristics and components being prepared for the payload. They are investigating such requirements as the precise power levels needed, the various radio frequencies to be employed and the achievement of a satisfactory heat balance within the satellite.

The "sweep frequency top-side sounding technique" is the term used by scientists to describe DRTE's method of investigating the structure of the ionosphere's upper levels. Scientists in DRB and elsewhere throughout the world have been probing the ionosphere for a number of years up to 200 mile altitudes by means of ground-based sounding equipment. The results obtained in the past relate mainly to the lower levels of the ionosphere because the higher levels are hidden above the ionosphere's most dense reflecting layer. The radio waves which penetrate through the dense ionosphere are lost in outer space and provide no information to the scientist on the ground. Canada's satellite is expected to fill this information gap by sounding or probing from above.

Soundings obtained when the satellite passes over the northern auroral zone will be of particular interest to Canada because of the special communications problems existing in high latitudes and Arctic regions during auroral disturbances.

The close association of DRB scientists with their NASA colleagues is a dramatic example of international collaboration in space science which undoubtedly will be extended in the future. The USA in particular has made clear its desire to extend this form of cooperation to other nations.

THE SCIENTIFIC EXPLORATION OF SPACE†

by G. D. Watson*

Defence Research Board

SUMMARY

The paper is a general interpretation of the use of space probes to obtain information about the solar system and interplanetary space. The mechanics of the most common orbits are described and typical space probes illustrated. Some of the scientific data obtained and some Canadian experiments are mentioned; and the question of the motivation for space exploration is discussed.

INTRODUCTION

On the 23rd February, 1909, J. A. D. McCurdy flew the Silver Dart a distance of ¾ mile at an estimated altitude of 60 ft. On the two succeeding days he flew 4½ miles and 20 miles. Those flights led to the rapid growth of Canadian aviation to the important position it now holds.

Just a few days less than 50 years after the flight of the Silver Dart at Baddeck, two instrumented nose cones, which had been constructed and tested by Canadians, were launched by rockets provided by the United States International Geophysical Year team at Fort Churchill. Although these events are relatively unspectacular in a year of earth satellite and space probe launchings, they do mark the first time a Canadian laboratory has been able to make direct measurements at an altitude of nearly 500,000 ft in the space above the atmosphere.

SPACE ENVIRONMENT

The new ability to make direct measurements of the properties of space, and the approaching era of manned space flight, has focused attention on the environment in which the space vehicle will operate. The word "space" has been used to indicate the volume in which the more solid objects in the universe exist. The word implies the relative state of void, or nothingness, which exists in large parts of the universe. The concentration of both mass and energy vary greatly throughout the universe. There are high concentrations of mass and there are stars that radiate high levels of energy but, in between, the levels of mass and radiated energy are extremely low. Nevertheless, if we start at the zero end of the scale, we soon learn that the space environment does contain significant amounts of gas, atomic nuclei, electrons, solid dust, meteoric material and electromagnetic radiation. Since the contents of space also vary significantly throughout the universe, we soon become involved in more specific names to describe particular regions. Examples are solar or interplanetary space used to describe space influenced by the earth, and "deep space", galactic space and intergalactic space to describe other parts of the universe. The words "near space", to describe space influenced by the earth, and "deep space" to describe the regions beyond, are also used.

Figure 1
Position of the solar system in the galaxy

Although scientists are interested in the limits of the universe and will strive to obtain information about those regions, space flight will be limited in the near future to a relatively small fraction of the interstellar distances, even though the distances covered will be much larger than those common in terrestrial travel. Manned space flight will not go beyond the solar system for many years and, even though it will soon be possible to launch space probes at velocities which would enable them to escape from the solar system, the prospects for communicating measurements back are not good under present conditions. Solar system space is therefore of particular interest to space flight engineers, whereas extragalactic space will be of interest to cosmologists and astrophysicists.

The solar system is located in one of the many galaxies that make up the universe. Some idea of scale can be obtained by examination of Figure 1. Our sun is located about 30,000 light years from the centre of a typical spiral nebula made up of many stars. The galaxy

†Based on a paper read at the Special Anniversary Meeting in Montreal on the 23rd February, 1959, and as revised for presentation to the Edmonton, Cold Lake and Winnipeg Branches of the C.A.I. in January, 1960.

*Scientific Adviser to the Chief of the General Staff.

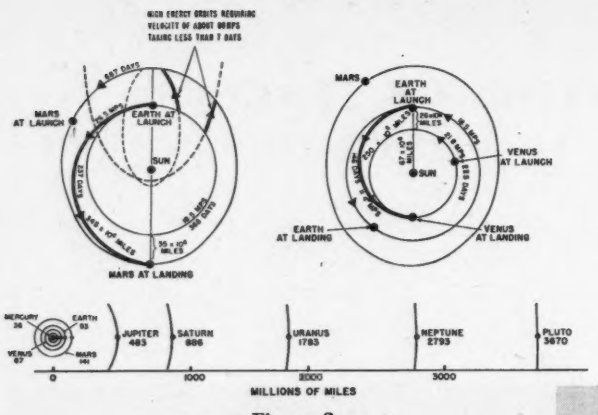


Figure 2
Solar system orbits

is about 100,000 light years in diameter and 10,000 light years thick. With these large dimensions it would take 30,000 years to travel to the centre of the galaxy at the velocity of light of 186,284 mps.

Solar system or interplanetary space

Solar system, or interplanetary space, Figure 2, is populated by the sun, the planets and their satellites, asteroids, meteors, comets and interplanetary dust. About 99% of the total mass of the solar system is concentrated in the sun, and a high percentage of the other 1% in the planets, leaving a very small amount of solid material in interplanetary space. The predominant feature of solar system space, from the point of view of space flight, is the radiation level from the sun and cosmic space. The sun radiates energy at all wave lengths from radio waves of many kilometres to short gamma rays of 10^{-8} cm in length and discharges atomic particles of relatively high energy. In addition to the solar radiation, similar electromagnetic energy and atomic particles known as "cosmic rays" penetrate solar system space from other parts of the universe. While the level of energy arriving from other parts of the universe is believed to be, for practical purposes, uniform throughout the solar system, the solar energy level varies inversely as the square of the distance from the sun and fluctuates with sun spot activity.

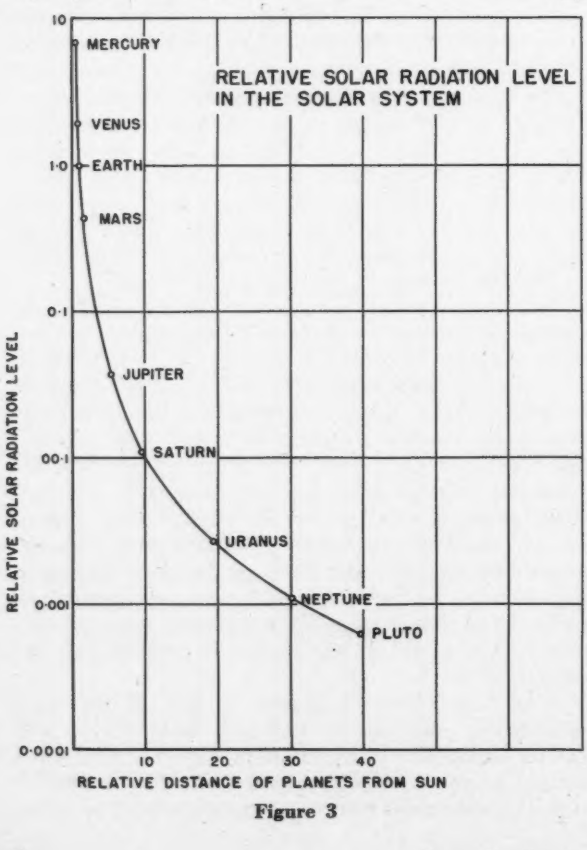


Figure 3

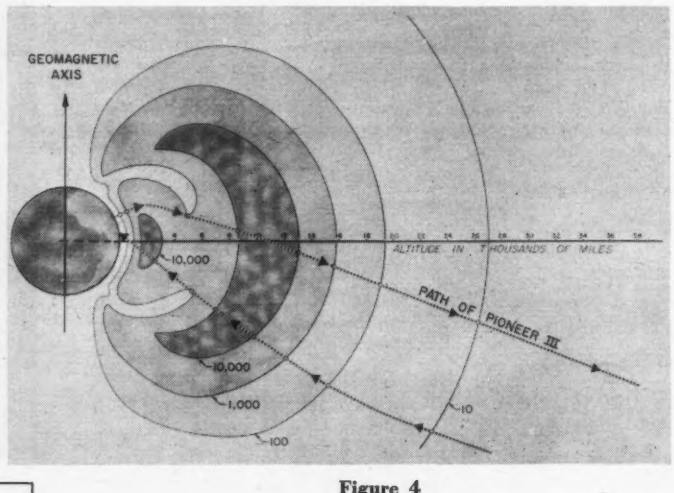


Figure 4
Van Allen radiation belts

Figure 3 illustrates the mean relative levels of solar energy at various planetary distances. It can be seen that the spacecraft designer will have to contend with a range of values from ten times the level incident on the earth to a level more than one thousand times lower. Additional information on the contents of space near the earth has been given by Millman[1], and an interesting paper on the physical nature of the planets and their probable course of evolution has been written by Heard[2].

Also, since the object of interplanetary travel will be to explore the planets and their satellites, the planetary atmospheres and the transition to interplanetary space will be of interest. An important discovery made by the use of satellites and lunar probes over the past year is that the earth has an influence on the space surrounding it to much greater distances than had previously been anticipated. It has been shown, Figure 4, that the earth's magnetic field traps solar or cosmic atomic particles, and others caused by secondary emission in the atmosphere, in such a way that the levels of radiation are many orders of magnitude higher than the corresponding levels outside the earth's influence. Similar conditions will probably exist for those planets that have magnetic fields and atmospheres and the condition existing in this "near space" of the planets will be of great interest to space flight engineers.

SPACE PROBES FOR SCIENTIFIC MEASUREMENTS

The generic name "space probe" has been given to the instrumented packages projected by rockets into orbits varying from vertical trajectories to the orbits for artificial earth satellites, lunar or planetary impacting probes, artificial satellites of the sun, planetary probes, and artificial planetary satellites. Very important information has already been obtained from vertical sounding rockets, earth satellites and lunar probes. The earth satellite technique will continue to be used to obtain information about near space and, as more thrust became available, the satellite technique has been extended to probe space out to and beyond lunar distances. Although it is not yet clear just how far the earth influences interplanetary space, there is a possibility that earth satellites of sufficient altitude can be launched to provide information effectively beyond the earth's influence. Under these conditions it is interesting to observe that an artificial satellite of the earth is travelling through interplanetary space not only at its own velocity but at the velocity of the earth's orbit, Figure 5, and that in addition to the distance travelled around the earth it would make approximately a 600,000,000 mile orbit around the sun sampling interplanetary space at the earth's distance from the sun. In addition, the solar system is believed to be rotating about the centre of the galaxy at 170 mps. Although the sun's influence on the space environment at the distance of the earth is likely to be predominant, and most of the solid components of the solar system space environment will be travelling with the sun, it is interesting to note that a probe of this kind will be sampling extragalactic elements of the local environment at a rate resulting from the combination of the 5 mps velocity of the probe, the 18.5 mps velocity of the earth and the 170 mps velocity of the solar system. It may be possible to separate the local space environment of the probe into components of solar system origin and those generated outside the solar system.

In addition to measuring the characteristics of space, the earth satellite is used to learn more about the earth

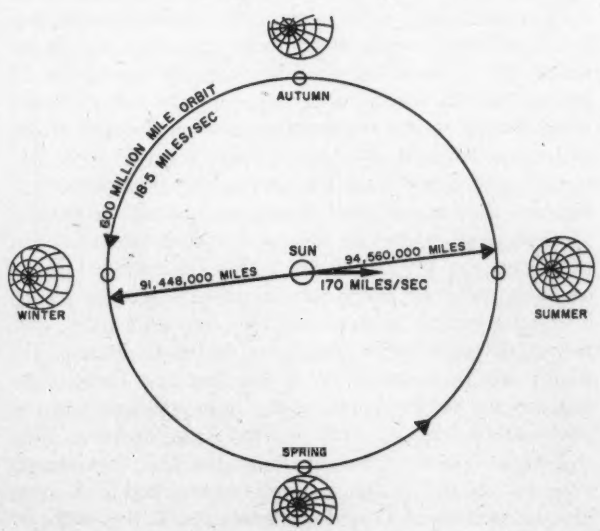
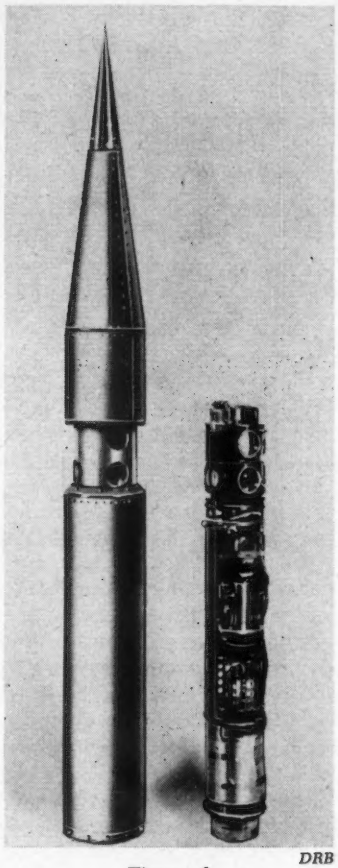


Figure 5
Earth orbital characteristics



DRB

Figure 6
Canadian infra-red nose cone

itself. For example, the meteorological satellites will provide information about cloud cover. Other satellites are designed to measure the magnetic field, density of the upper atmosphere, electron density in the ionosphere, the shape of the geoid[3] etc.

As soon as better communication with space probes has been established, or on-board power for orbital correction has been added, the artificial satellite of the sun will become an important device for determining the characteristics of interplanetary space. As is the case with the earth satellite, elliptical orbits of high eccentricity can be used as a technique to probe distances greater or less than the earth's distance from the sun.

As the control of probe technique improved, it has been possible to send instrumented probes to the near vicinity of the moon and, with further refinements, it will be possible to orbit instrumented packages around the moon or the planets. This technique can be used to obtain more detailed information about the planetary atmospheres, the influence of the planets on the local space environment, the nature of the surface of the planet and other characteristics of size, density, minerology etc. Unmanned planetary probes will undoubtedly be used to explore the moon and the planets before manned flights are attempted. Figures 6, 7 and 8 illustrate some typical examples of space probes instrumented for scientific measurements. Figure 6 is the Canadian vertical

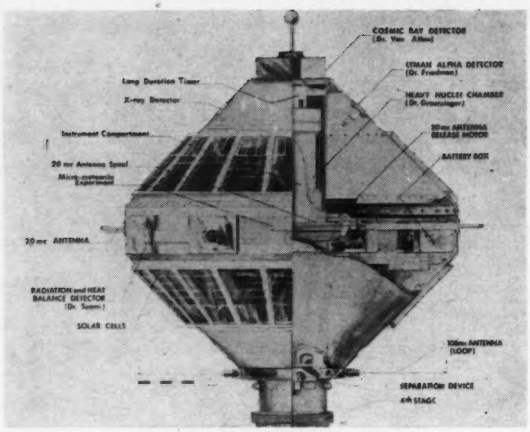
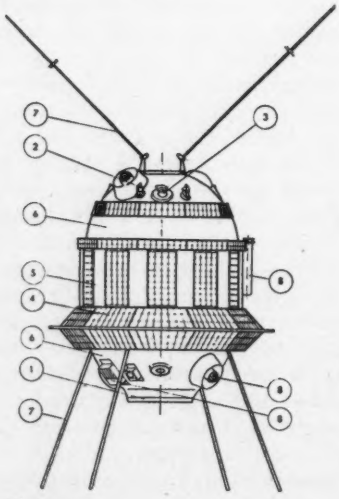


Figure 7
Engineering sketch of Explorer VII, showing the positioning of components

sounding-rocket nose-cone fired to high altitudes in the auroral belt near Fort Churchill to measure infra-red radiation. Figure 7 is the Explorer VII which carries equipment for seven different scientific experiments measuring radiation balance, Lyman-Alpha and soft x-rays, heavy primary cosmic rays, micrometeorites, cosmic ray distribution, solar cell performance in exposed locations and temperature at several points in the satellite. Figure 8 is Lunik III which took photographs of the far side of the moon.

Some of the Soviet lunar probe results were reported by Krasovskii[4]. He reports that the measurements of magnetic field in the vicinity of the moon indicate that the effective magnetization of the moon is not higher than 5% compared with the effective magnetization of the earth. He also reports that "within the error of measurements made close to the moon, there is no increase of intensity of hard corpuscular radiation as compared to that at a distance of some lunar radii. Cherenkov counters of hard charged particles also did not discover near the moon any deviations from that registered at a distance of several radii".



1. Illuminator for cameras; 2. Orientation system motor; 3. Solar monitor; 4. Solar batteries; 5. Thermo-regulation shutters; 6. Thermo screens; 7. Antennas; 8. Research Equipment

Figure 8
Lunik III—lunar probe

Although much greater payload capacity will be required, the value of an earth satellite could be greatly increased by the addition of a man, to attend to instruments, conduct visual observations and communicate with an earth based laboratory. As the technique improves further, a manned observatory on the moon will greatly increase the capability for observing the universe. Much larger telescopes could be usefully constructed there since the lack of atmosphere would remove the distortions caused by the earth's atmosphere which limits the useful size of telescopes. Such an observatory would extend the observable limit of the universe by a considerable amount. Furthermore, since the moon rotates on its axis only once a month and keeps the same face toward the earth at all times, a lunar based telescope would track at lower rates than on the earth, would have a clear sky at all times because of the lack of clouds and would be able to use an antenna for communication with earth which would only have to correct for the relatively small angular libration of the moon. If the magnetic field of the moon is as small as indicated above, and the trapped radiation belt negligible, the moon's influence on the space surrounding it may be small and it is possible that a permanent observing station on the moon might be as useful as space probes in sampling interplanetary space. The lunar station would be outside the main influence of the earth on space and would travel around the sun on a path similar to that which might be travelled by a solar satellite with the advantage that the distance to earth would remain constant at about a quarter of a million miles; a distance over which communication with earth is easy.

MECHANICS OF SPACE FLIGHT

Earth satellites

Although the vertically launched rocket is the simplest way to get transient scientific measurements in space, the earth satellite offers the opportunity for measurements over a relatively long time. To obtain an appreciable life, an earth satellite must be placed in an orbit at sufficient altitude that the earth's atmosphere does not create appreciable drag. A perigee height of about 200 miles is satisfactory as a minimum but as greater heights are required the minimum energy for a given height results from the use of an elliptical flight path in which the perogee remains a little above the earth's atmosphere while the apogee altitude is increased. Figure 9 illustrates the orbits used to increase the apogee of earth satellites out to and beyond lunar distance. By increasing the velocity from 25,900 fps required for a minimum orbit to 36,000 fps the probe can be increased in apogee height to approximately one-half lunar distance, and at an initial velocity of 36,400 fps the apogee height will correspond to lunar distance. These high eccentricity orbits represent the most efficient way to probe space out to a little beyond lunar distance. This technique is limited, however, by the fact that escape velocity of 36,750 fps is being approached and very precise control of velocity is necessary if the probe is to avoid escaping from the earth into an orbit of the sun. Furthermore, at an apogee height of about twice

lunar distance the earth's gravitational field is so small compared with that of the sun and moon that the orbit is no longer a stable two-body orbit and perturbations are likely to cause re-entry into the earth's atmosphere.

Circular orbits with the earth at the centre require greater energy as the height is increased but a space probe can be injected into a circular orbit from the apogee of an ellipse by adding thrust to increase the velocity when the path is at right angles to the direction of the earth, or by gradual acceleration to expand the orbit.

Lunar probes

Lunar probes have already been fired on several occasions[5].

If the gravitational field of the moon is taken into account, a velocity somewhat less than the velocity required to establish an earth satellite out to lunar distance can be used for lunar impact, and velocities in the vicinity of 35,000 fps are sufficient to allow lunar impact with a transit time of about 2½ days. This velocity is

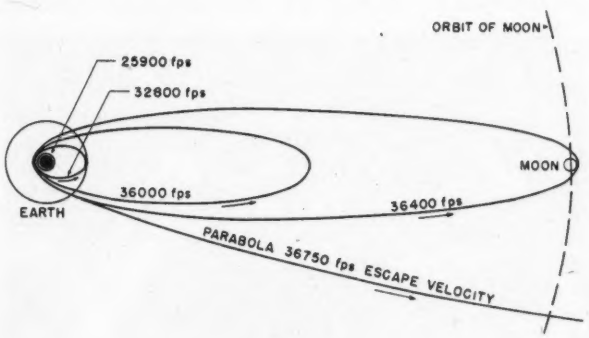


Figure 9
Space probe orbits

only about 1,700 fps below the escape velocity from the earth and the transit time, Figure 10, to the moon decreases rapidly from 2½ days to a little over 1 day as the velocity is increased from 35,000 fps to escape velocity of 36,745 fps. The accuracy requirements for lunar impact[5, 6, 7] have been computed and Cross and Jensen[5] indicate that for typical velocities in the neighbourhood of escape velocity the allowable angular tolerance is a few tenths of a degree, whereas the velocity tolerance is about 100 fps. As the velocity is decreased the demand for angular accuracy goes down because the lunar gravitational field becomes more effective in capturing the probe, but the velocity tolerance becomes more critical and is measured in a few feet per second. If a satellite of the moon is required, it is necessary to aim for a near miss and then reduce velocity when the probe's orbit is nearly parallel to the lunar surface. Since the orbital velocity of a lunar satellite is 2,000 to 5,000 fps less than the velocity which the probe will have, a braking rocket will be required to reduce the probe velocity by a corresponding amount, and if a lunar landing is to be made a further velocity decrease of approximately 7,000 fps will be required.

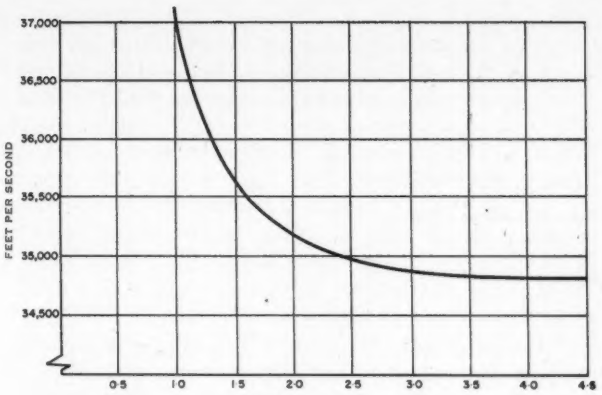


Figure 10
Earth-moon transit time — days

Solar satellites

From the discussion of earth satellite orbits going out to lunar distance it is evident that probes having apogee heights higher than the earth-moon distance require velocities at perogee approaching the velocity of escape from the earth. Any probe which reaches escape velocity will be travelling 18½ mps in the direction of the earth's orbit and will enter an orbit of the sun similar to that of the earth. The Soviet launching on the 1st January, 1959, is an interesting example of this technique because it combines the lunar probe technique with the near minimum energy solar satellite technique, Figure 11. The choice of time near to winter solstice offered advantages for the northern latitude launching site since the launch trajectory was more nearly coincident with the sun-earth-moon orbital planes. Timing the launch with the last quarter moon offered the opportunity to either hit the moon or pass near it and establish a solar probe orbit near to the earth's orbit. Figure 11 indicates the approximate conditions of the launch and the trajectory announced by the Soviet press. The probe is said to have passed approximately 4,460 miles from the moon at 9.57 pm, Eastern Standard Time, January 3, with a velocity relative to the moon of 5,472 mph. The moon at that time had passed the earth's orbit. Perihelion of the new orbit was reached on the 14th January, 1959. The

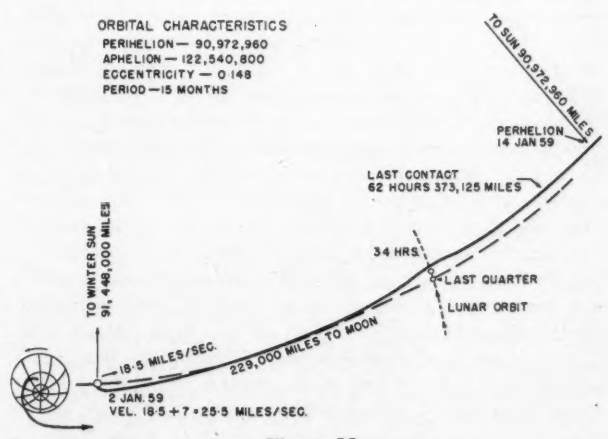


Figure 11
Probable orbit of the Soviet solar satellite

orbit is reported to have a perihelion of 90,972,960 miles from the sun and an aphelion of 122,540,000 miles with an eccentricity of 0.148. Radio contact was maintained for 62 hours and to a probe distance of 373,125 miles. The orbit is inclined at about 1° to the earth's orbit and has a period of about 15 months. See Reference 7 for a recent detailed report.

Interplanetary probes

Interplanetary probes can be launched using techniques similar to those just described but if near passes to the earth are required the orbits chosen must have periods which are an integral number of earth years. A typical high eccentricity orbit of this kind would intercept the orbit of Mars and return to the earth in two years. These probes will have limited value in exploring the planets, at least until they have sufficient power to correct orbit disturbances caused by the gravitational field of the planet. If the probe has no on-board power it must stay far enough away from the planet to avoid its trajectory being deflected in such a way that it will not return to within communication distance of the earth. Without power for orbital control, the accuracy requirement for return to a reasonable distance from earth is extreme and the probability of success relatively low.

Artificial satellites of the planets

The artificial satellite of the planets is the most interesting possibility for planetary investigation. A probe of this kind could be launched in a manner similar to that just described, but would require braking in the vicinity of the planet. While this seems unlikely to be possible until orbital velocity control, or perhaps even the manned probe, is available, the technique would allow close observation of the planet for relatively long periods during which the flight of the space probe would be fully controlled by the orbit of the planet. This procedure would allow measurement and photography to determine atmospheric characteristics, features of the surface of the planet, magnetic fields, trapped radiation, planetary atmosphere and the examination of possible future landing sites to proceed. Unfortunately this kind of mission can only be undertaken at certain times, because of the necessity for coordinating takeoff and landing times in such a way that the space vehicle will rendezvous with the planet. The easiest flight of this kind is to Mars. A typical launch would be similar to that of the Soviet Mechta probe but with slightly higher velocity. The probe would take about 260 days to travel to Mars, see Figure 2. If the probe comes within gravitational control distance of Mars it would then have to reduce speed and correct direction to establish a satellite orbit of Mars for an additional 485 days before Mars and Earth would be in suitable relative positions for the return journey of 260 days. Shorter duration missions could, of course, be carried out if much greater propulsive energy was available but if chemical fuels are to be used minimum energy orbits of the kind shown are highly desirable. Considering the difficulty of communications with earth, it can be seen that it may take a relatively long time – perhaps as much as 2.75 years after launch – before data can be returned to earth from a Martian scientific probe. Swerling[8] has analyzed communication requirements and his results indicate that about 100 watts of radiated power would be required to transmit a Martian picture in 14 hours between the orbits of the earth and Mars at nearest approach. Thus, until much greater payload capacity becomes available, the return of the probe to the vicinity of the earth will be necessary if data is to be returned.

SCIENTIFIC DATA OBTAINED BY SPACE PROBES

Although the launching of instrumented space probes only became possible about two years ago, a large amount of data is already available[9]. Both confirmatory and new information about the geophysics of the earth have been obtained. The earth's magnetic field has been fairly well explored out to several earth radii and a few measurements have been made out as far as the moon. The radiation belts trapped by the earth's magnetic field have been discovered and reasonably well charted. Their intensity and variability are sufficiently well known to indicate that they offer a problem to manned space flight which must be solved by shielding or choice of trajectory. There is evidence[4] that the moon has a relatively small magnetic field and little, if any, trapped radiation.

US Army

Figure 12

View of the earth, a mosaic of frames taken by the up-leg of an Atlas flight reaching an apex of 800 miles, reveals global sweep of the weather

Approximate values for the composition of the atmosphere in space have been measured up to about lunar distance. Stabilization of space probes has been accomplished and temperature control by balance between solar and probe radiation realized. Experiments on the effects of space flight on several kinds of animals has been undertaken including monkeys, dogs, mice and cats. Experiments exposing humans to weightlessness, isolation and other simulated conditions of manned space flight have been undertaken. First photographs of the earth, Figure 12, and the far side of the moon, Figure 13, and improved photographs of the solar surface, Figure 14, have been taken. Knowledge of the shape of the earth, the density of the atmosphere, the cloud cover, the nature of the ionosphere and aurora and the relationship between them and the magnetic fields of the earth and sun has been improved. A large increase in the detailed knowledge of orbital characteristics has been computed. Communication with satellites and space probes has been tested and revealed as a major limitation on the present capability to make measurements at more than a few

USSR

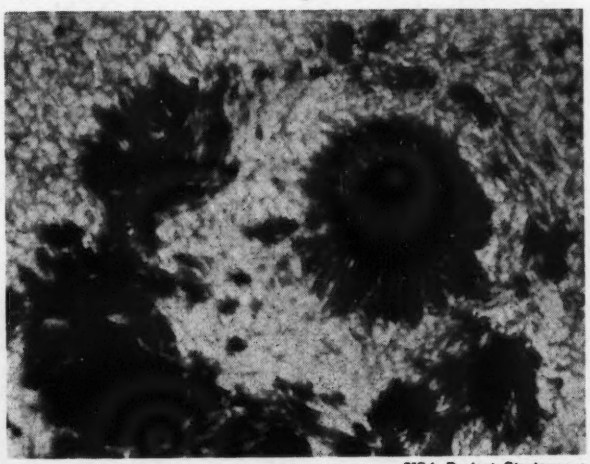
Figure 13
Far side of the moon

hundred thousand miles from the earth. Data will continue to be obtained and additional photographs of the moon and the earth can be expected in the near future. Photographs of Mars and Venus and measurements of the space environment near to these planets can be expected in due course.

CANADIAN SPACE RESEARCH

Scientists and engineers have been interested in the universe from the earliest days but until recently the observations on which they have based their theories about the universe have been obtained by relatively indirect methods. Canadians, like scientists of other nations, have studied cosmology, astronomy, physics, mathematics and biophysics of the universe. In more recent years some direct but transient measurements of the conditions in space just outside the earth's atmosphere have been undertaken by the use of vertical sounding rockets projected to high altitudes.

The interest in exploring the universe has increased very greatly since the demonstration in October, 1957, showed that it was now practical to launch earth satellites. Since that time the two great nations, the USSR and the USA, have made tremendous strides toward the practical exploration with scientific space probes and preparation for manned space flight. Both these nations have established national programs for exploration of the universe. Canadian scientists and engineers are naturally interested in these important developments. The formation of two Astronautical Societies and an Astronautics Section of the Canadian Aeronautical Institute has indicated the interest and desire for more formal exchange of scientific and technical information in the professional fields associated with space activities. In addition, many Canadians are members of the Institute of the Aeronautical Sciences, the American Rocket Society, the British Interplanetary Society, the Institute of Radio Engineers, and other organizations undertaking the exchange of information in the scientific fields relating to space flight. Many individuals in universities, national laboratories and industry have reoriented their thinking, and to a smaller extent their programs, along lines compatible with space activities.



USA Project Stratoscope

Figure 14
Solar surface showing sunspot penumbra on the 17th August, 1959, associated with a terrestrial magnetic storm the previous day

A number of scientific fields of particular interest in Canada have special application to space science. The fact that Canada is a large land area, and that it contains the North Magnetic Pole and much of the auroral belt, has lead to a relatively high interest in geophysics, upper atmospheric research, electromagnetic propagation, auroral and magnetic phenomena and cosmic rays. The relative inaccessibility of much of Northern Canada, with the consequent need for air transport and long range communications, and the special problems caused by magnetic and auroral disturbances, has lead to an unusual interest in navigation without magnetic references or extensive ground based navigation aids, and in the physics of radio propagation at long distances through auroral disturbances. In defence science, consideration of the protection against ballistic missiles has lead to an interest in hypersonic physics, rocket propulsion, re-entry phenomena, detection of space objects by radar and other means, and solar and celestial background radiation. All of these fields are of special interest in the scientific program for the exploration of space. Also, since much of our weather originates in the Arctic regions, meteorological observations, in many instances combined with ionospheric research, are undertaken at stations spotted throughout the Arctic regions. These observing points are a natural base on which to expand the communication with space objects. The most northerly land on Ellesmere Island has some special attractions from the point of view of observation of polar orbits since, being within 7° of the geographic pole, a station located there would be able to communicate with satellites in polar orbits on most, if not all, passes.

The extensive rocket program carried out by the United States International Geophysical Year activities at Fort Churchill, with some Canadian logistic support and the participation of Canadian scientists, was undertaken at that site because Churchill is in the middle of the auroral belt. A large number of rocket firings measured characteristics of the upper atmosphere and the ionosphere under varying amounts of auroral activity. Two of these rockets were instrumented by personnel of CARDE to measure infra-red background levels at altitudes up to about 100 miles. Although this is a minor

step compared with the space probes of the USSR and the USA, it is the first time Canadian instruments have been carried into the space environment above the atmosphere. In some respects the launching of these space probes corresponds to the first powered flight commemorated in 1959. It is satisfying to note the cooperation in science and engineering between the United States and Canada in both of these events.

Although much of the Canadian work in radio physics, long range communications, meteor and auroral observations of both the National Research Council and the Defence Research Board is of interest to space science, two experiments of DRTE are of special interest. In one, a large CW radar is used to reflect signals off the moon to measure attenuation, rotation of polarization, fading and other effects as the signal passes twice through the atmosphere, ionosphere and earth-lunar space. The results are of direct value in the field of space communications and in connection with telemetry of data and the determination of the position of earth satellites and space probes. Another interesting project involves the construction of an ionospheric radio sounder which will sweep its transmitter frequency from 2 to 15 megacycles. The sounder will be housed in a satellite, Figure 15, launched into a near polar orbit by the National Aeronautics and Space Administration in 1961. The technique will add information about the upper parts of the ionosphere at altitudes up to about 700 miles as compared with the limit of 200 miles for ground based experiments. It will also combine the data from Canadian ionospheric research stations with data obtained as the satellite passes over NASA stations in other parts of the world.

Another interesting experiment relating to the problem of weightlessness has been undertaken by DRML. It has been found possible to desensitize the balance organs of certain animals. These animals and others with normal balance reactions have been flown in an RCAF T-33 jet trainer on an orbit giving weightlessness up to 30 seconds to determine the importance of the balance organs in maintaining special orientation during weightlessness. It has been determined that the animal lacking normal balance organ sense was relatively at ease during weightlessness providing it retained its sense of vision, while the normal animal was profoundly disturbed by exposure to zero gravity both with normal vision and when blindfolded. The experiment indicates that while it may be possible to establish proper orientation visually under conditions of weightlessness, there may be a difficult psychological disturbance due to the lack of gravity reference. It has been reported recently that in aircraft flights giving similar short periods of weightlessness, some humans adapt easily to this new condition while others find it more difficult.

Figure 15
A mock-up of the "top-side sounder" satellite

MOTIVES FOR SPACE EXPLORATION

What are the motives for space activities?

Extraterrestrial exploration has begun and will lead eventually to exploration of interplanetary space, the planets and the satellites of the planets of the solar system. At some later time space probes and perhaps manned space flight will go beyond the limits of the solar system into interstellar space and eventually into intergalactic space. The limits appear to be determined by the lifetime of man and the long time required to travel to such great distances rather than the attainment of the necessary velocity.

Individuals, organizations, nations and even the United Nations are assessing the motives for participation. The extent to which participation is desirable becomes more difficult to assess as the level of organization increases but the position of science and engineering and the general benefits to society which will result from progress in space exploration are more easily perceived. The inate curiosity of man in his search for new knowledge, and the prestige associated with being the first to discover, will stimulate the exploration of the universe to the extent possible with a reasonable proportion of the available resources. Space technology is in its infancy, and it is clear that many existing techniques and equipments are marginal or inadequate. There is tremendous effort being applied to improve technology and equipment. A stimulus to science and technology has always resulted in many by-product benefits to the world and the stimulus provided by the exploration of space will be no exception. Although many by-product possibilities exist the following will illustrate typical examples:

(a) Improved communications through improved equipment and by the use of satellite relay points. A television relay in 24-hour orbit could be used to provide wide coverage from a single point. Whether

this will be practical before a manned relay station is available will depend on the reliability of the equipment.

(b) Improved weather forecasting as a result of rapid and complete cloud surveys made from satellites. (See Figure 12.)

(c) Improved knowledge of geophysics with resultant improvements in mapping and mineral and petroleum exploration.

(d) Improvements in intercontinental travel. The examination of hypersonic transport aircraft travelling at near orbital velocities have been the subject of considerable study[10, 11]. Improvements in propulsion, reentry physics, cabin design and navigation offer the possibility of economical high speed transportation at intercontinental ranges. The extreme demand for higher thrust and greater efficiency will improve chemical and nuclear engines and their fuels with resultant improvements in engines used in many different applications.

(e) The extreme demand for high reliability will result in improvements in a large range of electronic, mechanical and chemical equipment which can only be of benefit to the users of similar equipment in non-space applications.

(f) The high level of radiation, which is now known to surround the earth, will stimulate examination of the physiological effects of radiation on humans and the protection necessary for man's existence in an environment with relatively high radiation levels. This will result in improved knowledge of the effects of radiation on the human which will have general benefit.

(g) The possibility of establishing manned astronomical observations either in artificial satellites of the earth, or on the moon itself, offers the scientist a new and improved means of exploring the universe without the presence of the earth's atmosphere which tends to obscure and distort his ability to observe at great distances. This will enable cosmologists and astronomers to obtain new information of value in explaining the nature of the universe.

The position of the individuals in fundamental research and basic technology is relatively clear. Space exploration will provide new facts in practically every field of scientific activity offering the opportunity for individual scientists and engineers to use these new facts to advance the knowledge in their special branches of science. Much has been said about the necessity for team work in space exploration and this is certainly desirable in the actual accomplishment of space flight; on the other hand, science is probing to new depths in the specialist fields and the present age can certainly be described as one in which the individual must concentrate on deep and penetrative thought using the new information to formulate new theories and invent new techniques. In the engineering fields the demand for inventiveness is as great as it has ever been, and the scope for new inventions in space navigation, propulsion using energy of the space environment, space ship stabilization and orientation, space communications, space cabin design, food technology, simplified computational techniques for space orbital determination, long range miniaturized communication, and computational and automatic control equipment, all demand the utmost in skill from the engineer.

REFERENCES

(1) Millman, P. M. — *The Contents of Space Near the Earth*, Canadian Aeronautical Journal, Vol. 5, No. 9, p 358, November, 1959.

(2) Heard, J. F. — *The Physical Nature of the Planets and Their Probable Course of Evolution*, Canadian Aeronautical Journal, Vol. 5, No. 5, p 184, May, 1959.

(3) O'Keefe, J. A. — *IGY Results on the Shape of the Earth*, ARS Journal, Vol. 29, No. 12, December, 1959.

(4) Krasovskii, V. I. — *Results of Scientific Investigations made by Soviet Sputniks and Cosmic Rockets*, ARS Journal, Vol. 30, No. 1, January, 1960.

(5) Cross, D. B., and Jensen, J. — *A Survey of Propulsion and Space Dynamics*, Journal of the Astronautical Sciences, Vol. V, No. 1, Spring, 1958.

(6) Michelwait, A. B. — *Lunar Trajectories*, ARS Journal, Vol. 29, No. 12, December, 1959.

(7) Sedov, L. I. — *Orbits of Cosmic Rockets Toward the Moon*, ARS Journal, Vol. 30, No. 1, January, 1960.

(8) Swerling, P. — *Space Communications*, IRE Transactions on Military Electronics, Vol. MIL 2, No. 1, December, 1958.

(9) Newell, H. E., Jr. — *U.S., Russian Space Efforts Compared*, Aviation Week, December 21, 1959.

(10) Cornog, R. A. — *Commercial Rocket Airplane: a connecting link to Manned Space Flight*, Paper 710-58, Presented at the ARS 13th Annual Meeting, New York, 17-21 November, 1958.

(11) Goodmanson, L. T. — *Supersonic Transports — Some Design Aspects*, Canadian Aeronautical Journal, Vol. 6, No. 2, February, 1960.

(12) Robillard, G. — *Explorer Rocket Research Program*, ARS Journal, Vol. 29, No. 7, July, 1959.

(13) Bucheim, R. W., and staff of Rand Corporation, Space Handbook, Random House, New York, 1959.

(14) Newbauer, J. A. — *Ringing in the Future — a description of the seven experiments of Explorer VII*, Astronautics, Vol. 4, No. 12, 1959.

(15) Watson, G. D. — *Astronautics — Science of Space Exploration*, Canadian Aeronautical Journal, Vol. 4, No. 6, June, 1958.

(16) Buckheim, et al — *Some Aspects of Astronautics*, IRE Transactions on Military Electronics, Vol. MIL 2, No. 1, December, 1958.

(17) Steven, H. G. — *Our Interest in Space and its Technology*, IRE Transactions on Military Electronics, Vol. MIL 2, No. 1, December, 1958.

(18) Melin, M. — *Observing the Satellites*, Sky and Telescope, Vol. XIX, No. 2, December, 1959.

(19) Astronautical Annual 1959, Astronautics, Vol. 4, No. 11, November, 1959.

(20) Miekelwait, A. B., Tompkins, E. H. Jr., and Park, R. A. — *Three-Dimensional Interplanetary Trajectories*, IRE Transactions on Military Electronics, Vol. MIL 3, No. 4, October, 1959.

(21) Dryden, H. L. — *Recent Trends in Aeronautics and Space Research in the United States*, Canadian Aeronautical Journal, Vol. 5, No. 9, November, 1959.

(22) Blagonravov, A. A. — *Some Problems of Providing Scientific Research on Rockets*, ARS Journal, Vol. 30, No. 1, January, 1960.

(23) Gilzin, Karl — *Travel to Distant Worlds*, USSR Foreign Languages Publishing House, Moscow, 1959.

(24) Corkhill, de Paul T. and Hoffmann, R. A. — *Detection and Evaluation of Space Radiations*, IRE Transactions on Military Electronics, Vol. MIL 3, No. 4, October, 1959.

A PRELIMINARY ANALYSIS OF THE PENALTIES ASSOCIATED WITH PIERCING A WING TORSION BOX WITH A GRID OF HOLES†

by A. H. Hall*

National Research Council

SUMMARY

This analysis relates to a conventional aircraft that is modified by the addition of fans housed in the wing plane to provide means for vertical takeoff and landing. The influence of a grid of holes in the wing torsion box, on top level speed, is inferred by the torsional stiffness criterion for wing divergence. The probable weight penalty incurred in restoring the stiffness to its original, or an intermediate value, is estimated.

INTRODUCTION

It has been suggested that vertical takeoff assist can be given to a conventional aircraft by placing a number of fans in holes which penetrate the top and bottom surfaces of the wings. (The aerodynamic characteristics of this arrangement were considered in Reference 1.) The purpose of this analysis is to provide a preliminary estimate of the structural weight and stiffness penalties involved, and to estimate the effect on level flight performance.

The restoration of bending stiffness after cutting holes in the wing structure presents no great problem, provided the hole diameters are not too large. Restoration of torsional stiffness is much more difficult, and much more important, because a reduction in torsional stiffness can cause a reduction in the design dive speed and hence the speed of level flight. Consequently, the following analysis is restricted to a study of torsional stiffness as it affects design dive speed when it is allowed to deteriorate, or as it affects weight when it is maintained at the original, or a reasonable, level.

The analysis applies to a conventional rectangular wing without sweep, in which the stiffness of a unit torsion cell including one hole can be taken as representative. Since only relative performance is discussed, the analysis is simplified because the relative performance of unit cells can be assumed to represent the relative performance of the built-up wing box.

SPEED PERFORMANCE CRITERION

The minimum torsional stiffness requirements of conventional aircraft wings are dictated by a wing torsional stiffness criterion[2] which states that

$$\frac{1}{V_D}\left(\frac{k}{dc^2}\right)^{1/2}(1 - M^2)^{1/4} \not< N \qquad (1)$$

where N = a prescribed numeric
V_D = design dive speed
c = mean wing chord
d = distance from wing root to 0.9 span
k = torsional stiffness at 0.75 span
M = Mach number appropriate to $V_D (M = 0.8)$

If it is assumed that the original wing design is efficient to the extent that the torsional stiffness just satisfies Eq. (1), then a change in stiffness will be reflected by a change in the allowable design dive speed. From Eq. (1), ignoring Mach number effects, a dive speed performance criterion is obtained, viz,

$$\frac{V_D}{V_{D_o}} = \sqrt{\frac{k}{k_o}} \qquad (2)$$

where the subscript o refers to the original wing. The speed of level flight must necessarily be less than V_D.

STIFFNESS ANALYSIS

To obtain maximum stiffness of the wing torsion box, the skin should not buckle. It is therefore assumed that the material taken from the holes is applied to the free edge for the purpose of raising the critical shear stress

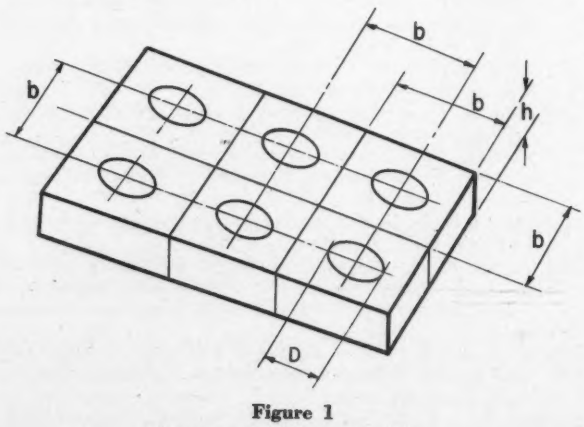


Figure 1
Arrangements of perforations

†This paper is based on N.A.E. Laboratory Report LR-236.
*Senior Research Officer.

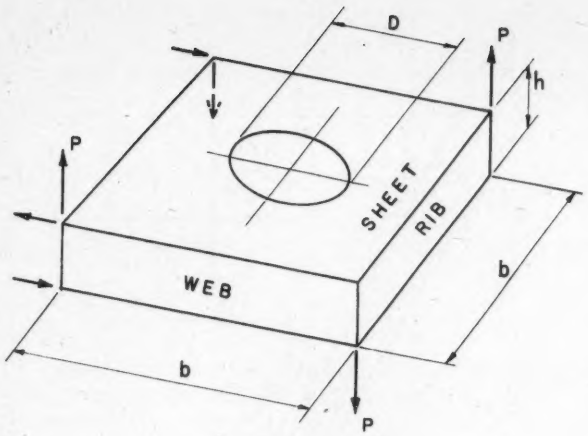


Figure 2
Unit torsion cell

so that buckling does not occur below at least the proof load (⅔ ultimate). The original ultimate strength may therefore be retained although deformations can be extremely large.

If the perforation consists of a rectangular grid of circles of diameter D (Figure 1) the stiffness of the whole can be monitored by the stiffness of a unit box. In plan, the box is square with sides equal to the perforation pitch b, and contains one hole in the centre. The sides of the box (depth h) are enclosed by spar webs (spanwise) and ribs (chordwise). The box is twisted by a bicouple Pb (Figure 2). Assume that the original thickness of the webs, ribs and sheet is t, and that the panel with a cut-out behaves as though it has an effective thickness t_{eff}.

The shear stresses acting along the edges of webs, ribs and sheet will be shown in Figure 3. The energy per unit volume of a sheet with shear stresses u and v acting along its edges is given by

$$E = \frac{uv}{2G} \tag{3}$$

where G is the shear modulus. Hence, the energy stored in a rib will be

$$U_{rib} = \frac{uv}{2G} \cdot bht = \frac{1}{2Gt} \cdot \frac{b^2}{h^2} \cdot p^2 \tag{4}$$

The energy stored in a web will be the same,

$$U_{web} = \frac{1}{2Gt} \cdot \frac{b^2}{h^2} \cdot p^2 \tag{5}$$

The energy stored in a surface panel will be

$$U_{sht} = \frac{1}{2Gt_{eff}} \cdot \frac{b^4}{h^4} \cdot p^2 \tag{6}$$

The total energy stored in the box will therefore be

$$U_{total} = \frac{2p^2}{2G}\left(\frac{b^2}{h^2t} + \frac{b^2}{h^2t} + \frac{b^4}{h^4t_{eff}}\right) = \frac{p^2}{G}\left(\frac{2b^2}{h^2t} + \frac{b^4}{h^4t_{eff}}\right) \tag{7}$$

Corresponding with the force P, there will be a deflection amounting to

$$\delta = \frac{\partial U_{tot}}{\partial P} = \frac{2P}{G}\left(\frac{2b^2}{h^2t} + \frac{b^4}{h^4t_{eff}}\right) \tag{8}$$

Introducing the twist θ, and torsional stiffness k, where

$$\left.\begin{aligned} \delta &= b\theta \\ k &= \frac{Pb}{\theta} \end{aligned}\right\} \tag{9}$$

we obtain

$$k = \frac{h^2Gt}{2\left(2 + \frac{b^2}{h^2} \cdot \frac{t}{t_{eff}}\right)} \tag{10}$$

The effective sheet thickness can be defined as

$$t_{eff} = \eta t \tag{11}$$

where η depends in part upon the manner in which the free edge of the cut-out is reinforced and the thickness of the shear panel. Kuhn[3] has obtained an empirical relation in the case of flanged holes in sheet material in the neighbourhood of 0.040 in to 0.064 in thick. The flange material supporting the panel edges was stiff. Kuhn's thickness coefficient is

$$\eta = 1 - \frac{D}{b} \tag{12}$$

where D is the diameter of the hole, and b is the plate width.

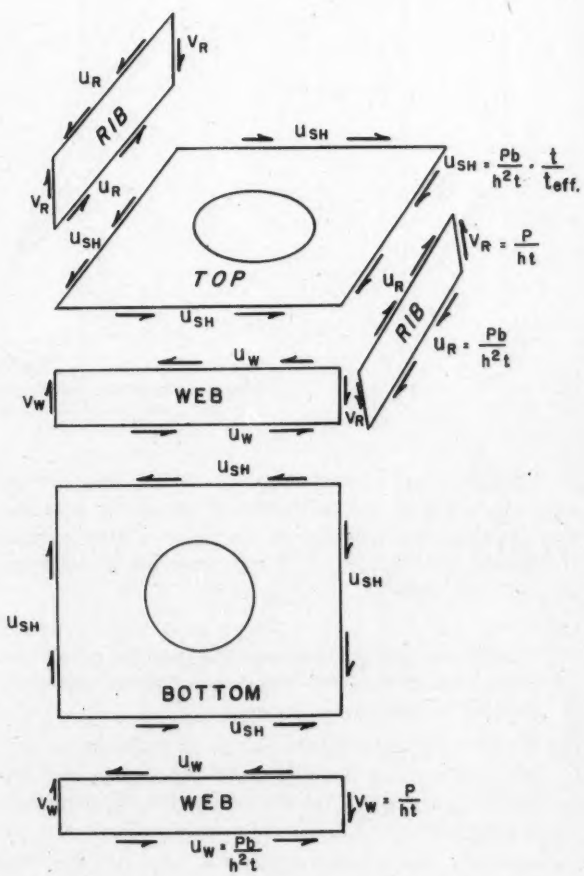
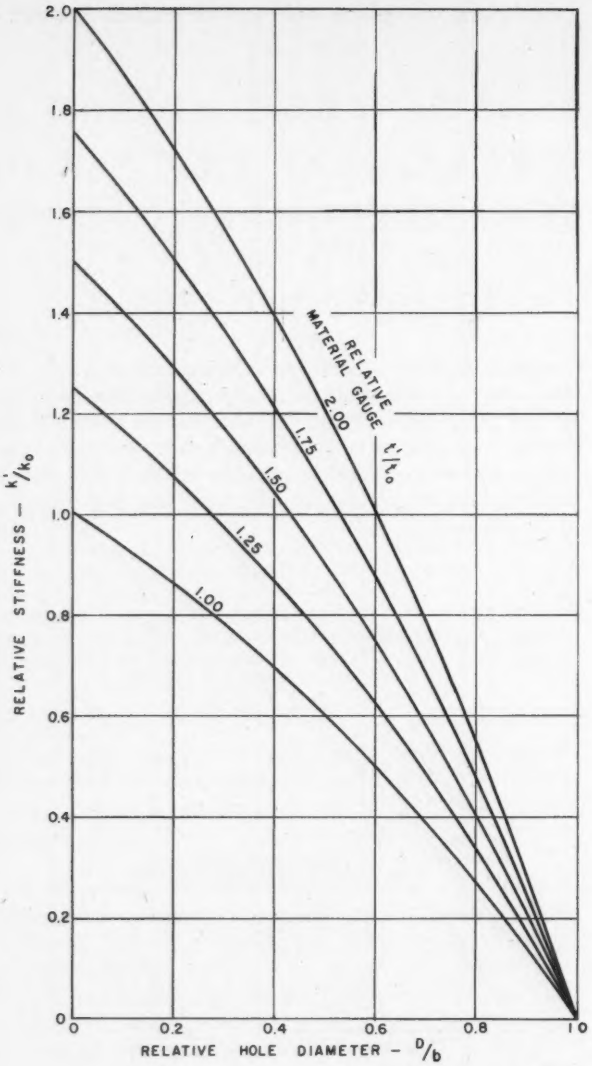
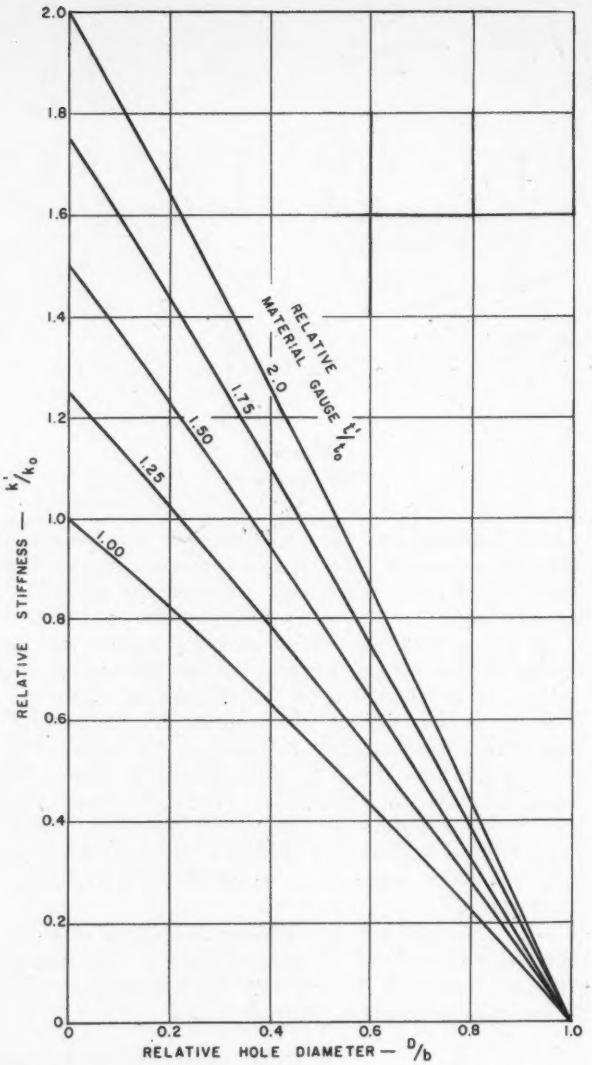


Figure 3
Force-deformation system





Figures 4 and 5
Effect of hole size and material gauge on the relative stiffness of the perforated cell, with $b/h = 2.0$ and 4.0 respectively

Reinforcement around the edge of the hole can assure[4] the required critical buckling stress, but will not alter the shear stiffness appreciably unless a large volume of material is added. Eq. (12) can therefore be used for the following reasons:

(a) If the modified wing is to be kept at the original weight, the material removed and used for reinforcement around the hole will not constitute sufficient volume to change the stiffness.

(b) If the wing is to be reinforced to maintain its original stiffness, a large amount of material will be added but in a manner more effective than concentrating it around the cut-out.

Consequently, the relative stiffness k', of a cell that has been modified by the addition of holes and a change in material gauge t', will be, from Eqs. (10), (11) and (12),

$$\frac{k'}{k_o} = \frac{t'}{t_o} \cdot \frac{\left(2 + \frac{b^2}{h^2}\right)}{2 + \frac{b^2}{h^2\left(1 - \frac{D}{b}\right)}} \qquad (13)$$

where the subscript o refers to the original cell, and the prime refers to the cell modified with holes and material gauge.

Eq. (13) has been plotted in Figures 4 and 5, and the transformation of these data to design dive speed through Eq. (2) is shown in Figures 6 and 7.

HOLE DIAMETER FOR MAXIMUM STRENGTH/WEIGHT RATIO OF THE SHEET PANELS

A maximum strength/weight ratio exists for the perforated shear panels, although the strength for this optimum condition may not be as high as for the original

panel. The formulation is again Kuhn's, although a slight adjustment is required for the present application. The maximum strength/weight ratio for shallow ribs with flanged holes, from Reference 3, is

$$R = A \pm \sqrt{A^2 - B} \tag{14}$$

where R is the optimum value of $\frac{D}{b}$

$$A = \frac{4d}{\pi D} \text{ with } d \text{ the web depth} \tag{15}$$

$$B = A + \frac{\tau_{cr}\,(1 - A)}{\tau_{ult} - \tau_{cr}} \tag{16}$$

Since it has been assumed that the perforated panels do not buckle below proof load, we can write

$$\tau_{cr} = \tfrac{2}{3}\,\tau_{ult} \tag{17}$$

From Eqs. (14) and (16)

$$\left(\frac{D}{b}\right)_{opt} = A \pm \sqrt{A^2 + A - 2} \tag{18}$$

If we now substitute b for d in Eq. (15) which tacitly assumes that the edges of the shear panel are supported by stiff flanges,

$$\left(\frac{D}{b}\right)_{opt} = \frac{4}{\pi} \cdot \frac{1}{A} \tag{19}$$

so that

$$A^2 - \left(2 - \frac{8}{\pi}\right) A^2 - \frac{16}{\pi^2} = 0 \tag{20}$$

and

$$A \approx 1.4 \tag{21}$$

or

$$\left(\frac{D}{b}\right)_{opt} = 0.91 \tag{22}$$

Reference to Eq. (13) will show that (at constant weight) the stiffness loss is too great to use the above optimum hole diameter and, as will be seen later, the weight required to re-establish the original stiffness would also be prohibitive.

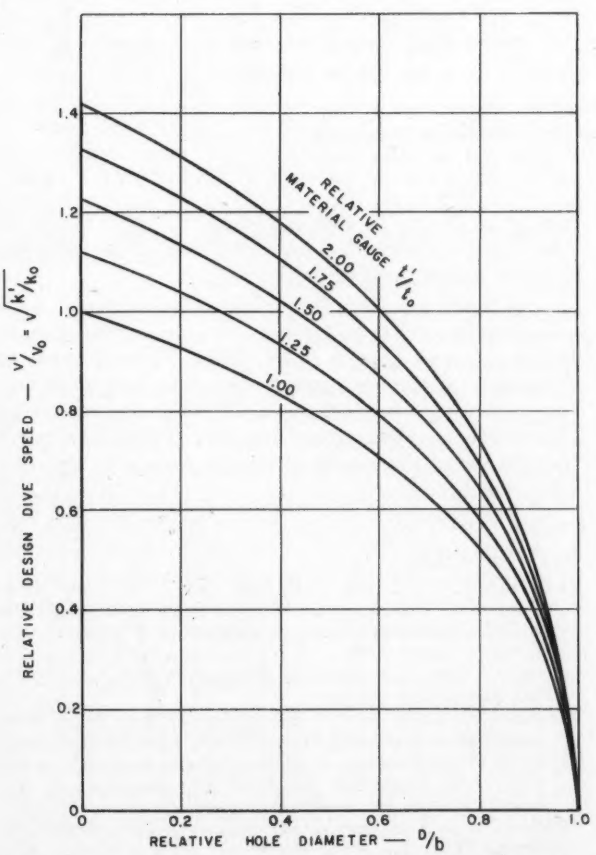
WEIGHT-STIFFNESS ANALYSIS

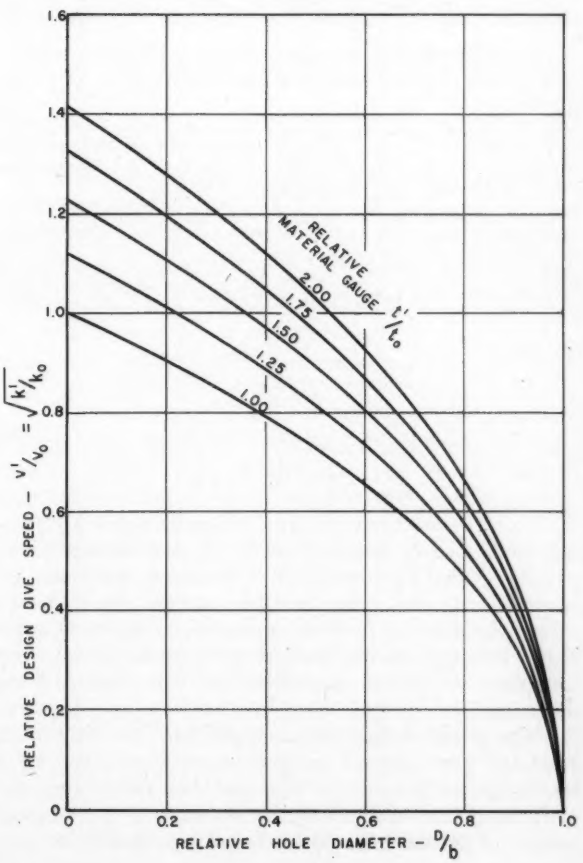
The weight of the unit cell originally is

$$W_o = \rho t_o\,(2b^2 + 4bh) \tag{23}$$

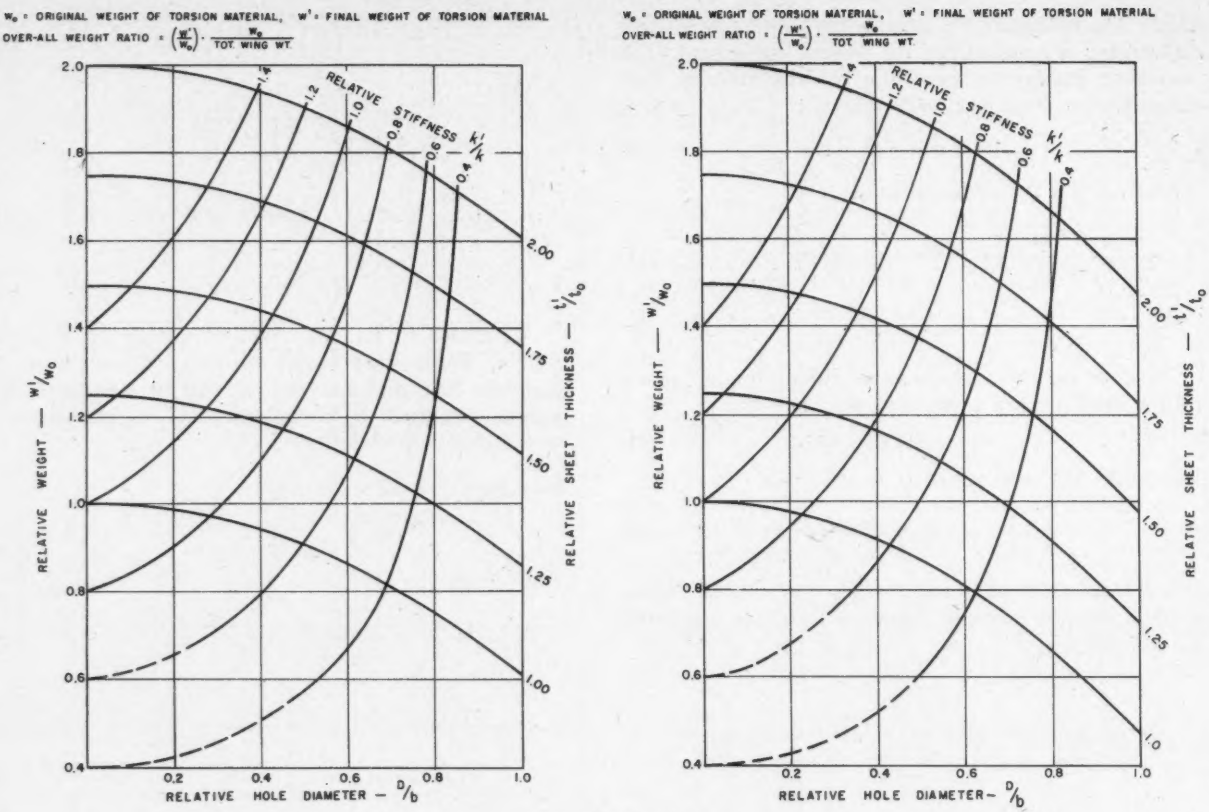
With holes,

$$W = \rho t_o \left\{(2b^2 + 4bh) - \frac{\pi D^2}{2}\right\} \tag{24}$$





Figures 6 and 7
Effect of hole size and material gauge on the design dive speed of a perforated wing with torsion boxes represented by $b/h = 2.0$ and 4.0 respectively



Figures 8 and 9
Effect of hole size on weight, when the stiffness is readjusted by altering the material gauge, $b/h = 2.0$ and 4.0 respectively

If the gauge of the remaining material is changed to t', then

$$W' = \rho \left\{ (2b^2 + 4bh)\, t' - \frac{\pi D^2}{2} t_o \right\} \tag{25}$$

so that

$$\frac{W'}{W_o} = \frac{t'}{t_o} \cdot \frac{\left(2 + \frac{4h}{b}\right) - \frac{\pi}{2}\frac{D^2}{b^2}}{\left(2 + \frac{4h}{b}\right)} \tag{26}$$

Eq. (26) has been plotted in Figures 8 and 9. Superimposed on these diagrams are the constant stiffness lines obtained from Figures 4 and 5. Assuming that holes are placed along the wing span at intervals equal to the chordwise dimension of the torsion box, Figures 8 and 9 show the approximate weight penalty associated with complete or partial restoration of the original wing stiffness.

The above weight ratios apply only to the torsion material. The over-all weight factor appropriate to a particular wing must be obtained by multiplying the right hand side of Eq. (26) by the ratio of the original weight of torsion material to the total wing weight.

CONCLUSIONS

(a) The effect on design dive speed of a rectangular grid of holes in the wing torsion box will be approximately as shown in Figures 6 and 7. These diagrams relate to a wing that has been modified by the addition of holes and/or material gauge.

(b) The estimated weight penalties associated with complete, or partial, restoration of wing stiffness can be obtained from Figures 8 and 9. These diagrams apply to the weight of torsion material only. The weight factors appropriate to a particular over-all wing weight can be obtained by multiplying the ordinates of Figures 8 and 9 by the ratio of the weight of torsion material to the total wing weight.

REFERENCES

(1) Wardlaw, R. L., and McEachern, N. V. — *Some Aerodynamic Characteristics of Wing-Mounted Lifting Fans for VTOL Applications*, CANADIAN AERONAUTICAL JOURNAL, VOL. 5, No. 3, MARCH, 1959.

(2) BRITISH CIVIL AIRWORTHINESS REQUIREMENTS, CHAPTER D3-9, AIR REGISTRATION BOARD.

(3) Kuhn, P. — *The Strength and Stiffness of Shear Webs With and Without Lightening Holes*, NACA ARR 35, JUNE, 1942.

(4) Kroll, W. — *Instability in Shear of Simply Supported Square Plates with Reinforced Holes*, US BUR. STANDARDS, J. RESEARCH, VOL. 43, No. 5, (RP 2037) P 465, NOVEMBER, 1949.

(5) Kuhn, P. — *The Strength and Stiffness of Shear Webs with Round Lightening Holes Having 45° Flanges*, NACA ARR 158, DECEMBER, 1942.

(6) Levy, S. — *Computation of Influence Coefficients for Aircraft Structures with Discontinuities and Sweepback*, J. AERO. SCI. VOL. 14, No. 10, P 547, OCTOBER, 1947.

PRECIPITATION PHYSICS RESEARCH IN EASTERN CANADA†

by A. D. Wood*

National Aeronautical Establishment

At the request of the Meteorological Branch of the Department of Transport, the Flight Research Section of NAE has entered into an extensive programme of weather research. The purpose of the work is to obtain a better understanding of the physics of precipitation in eastern Canada by the direct observation of cloud characteristics and measurements of rainfall over test areas. Meteorologists are uncertain of the precise natural processes which govern the development from water vapour of drops large enough to fall as rain and of the exact differences in atmospheric conditions and cloud structures which account for the large variations in rainfall often recorded at places not far apart. A scientific project designed to obtain reliable information on this problem requires a closely controlled airborne operation and a well supervised network of ground observation points. The Flight Research Section is responsible for the airborne phase of this work and carried out a preliminary eight-week operation during the summer of 1959.

The region chosen for ground observations consists of two squares each having a side length of 32 nautical miles and separated by a similar distance. Sixteen observation stations were evenly distributed over each square and there was a complete weather station at Angliers and Macamic near the respective centres. Cooperating with the Meteorological Branch in organizing this ground network were the Forestry Branch of the Department of Northern Affairs and National Resources, the Canadian Pulp and Paper Association and various forest industrial organizations in the region. In addition to rainfall measurements, records were obtained of lightning activity in the region and the RCAF provided supplementary information on precipitation as indicated by ground radar presentations.

The weather systems of primary interest are storms consisting either of frontal systems or troughs, and one objective of the airborne operation is to determine the effect on precipitation of seeding such storms from the air with silver iodide. The two ground areas have been chosen so that the effects of seeding may be assessed during the course of several summer operations by flying upwind of one or other area. The area to be seeded is selected at random on each flight and the uncontaminated area is used as a control.

Figure 1
B25 Mitchell aircraft equipped for precipitation physics experiments

The requirements for flying under bad weather conditions for a considerable number of hours and for carrying instrumentation and observers necessitate an aircraft of moderate size. A B25 Mitchell was regarded as suitable and an aircraft of this type was made available by the RCAF for use on the project. This aircraft (Figure 1) has been fitted with an ice detector, a hot wire liquid water content meter, cloud droplet micro-photographic equipment, a non-wetting thermometer, a flight recorder and a counting accelerometer (Figure 2). In addition, a freezing nuclei generator designed in Australia has been constructed and installed in a streamlined pod under the port wing of the aircraft (Figure 3). This generator releases the smoke resulting from the combustion of a mixture of silver iodide and acetone. A tank in the forward part of the pod contains

†A similar article appeared in the Quarterly Bulletin of the Division of Mechanical Engineering and the National Aeronautical Establishment, July to September, 1959.

*Head, Flight Research Section

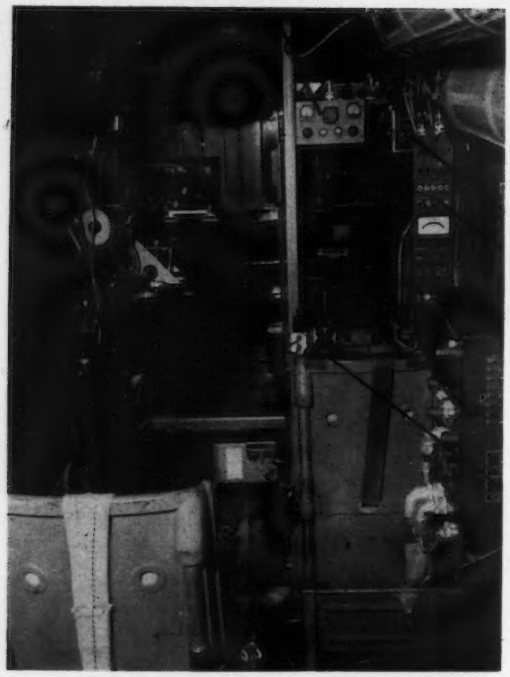


Figure 2
Rear fuselage compartment of Mitchell aircraft showing observers' stations and instrumentation

a quantity sufficient for 10 hours of operation at the design consumption of two gallons per hour. A freezing nuclei counter will be installed for future operations but was not available for the work during the past summer.

The potential advantage of seeding from the air rather than from generators located on the ground stems from the fact that the particles are introduced at the appropriate level in the cloud and with a known concentration. Furthermore photolytic inactivation of the particles before reaching the cloud is avoided. The level chosen for the experiments was midway between the cloud base and the height at which the temperature was −5°C. At this level the point of release of the particles was required to be 15 minutes at wind speed upwind of the target area. Lateral diffusion of the particles was assumed to be confined within a cone having a semi-vertex angle of 10°. In general, seeding was only carried out following the onset of precipitation. In order to minimize the danger of contaminating the control area the two areas were aligned at right angles to the predominant westerly wind. The aircraft was flown at right angles to the actual wind on a series of reciprocal courses at the required distance upwind of the target area. Boundaries making allowance for a diffusion angle of 10° and passing through the nearest point of the control area were used to define the limits of the seeding runs for various true directions of the wind between 220° and 320°.

The maintenance of these precise seeding patterns, which in turn required accurate wind determination in flight at frequent intervals, all under instrument flying conditions, made unusual navigational demands. To meet these demands the aircraft was fitted with Decca navigational equipment (Figure 4), and a survey-type ground chain was set up in Northern Ontario with the master station at Matachewan and slave stations at Emerald Lake (Figure 5) and Cochrane. The aircraft equipment included a Flight Log in the cockpit which recorded on a chart the track and position of the aircraft. As an alternative, but less accurate, aid to navigation use

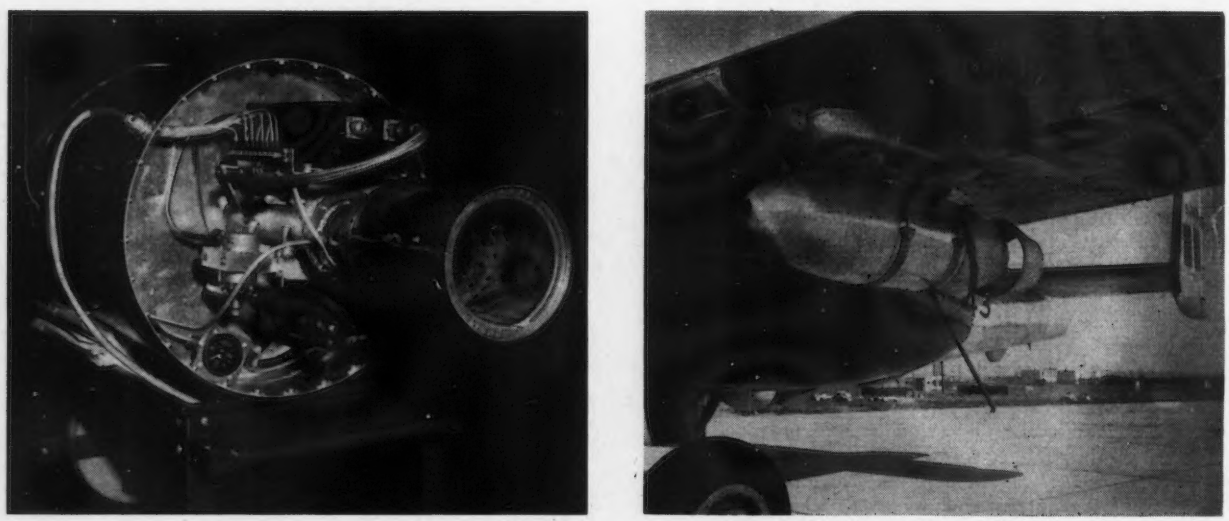


Figure 3
Silver iodide generator showing arrangement of components and installation on wing bomb-rack

Figure 4
Mitchell aircraft cockpit fitted with Decca navigation equipment

has been made of the control facilities afforded by the military radar network.

To increase the flying time available at the target a forward base of operations was established at Val d'Or, Quebec. In general, the aircraft was flown from Uplands to Val d'Or when preliminary warning was obtained of an impending storm. The aircraft was then refuelled and the crew, consisting of two pilots, a crewman and two observers, rested in readiness for takeoff at short notice.

The decision to carry out an operation was made by the meteorologist attached to the project at Uplands. Telephone communications were used to alert the flight crew at Val d'Or, the Decca master station at Matachewan and the weather stations at Macamic or Angliers. The Decca master station was in radio communication with the two slaves. Once in the air the aircraft was able to communicate directly by radio with the Decca master station. Depending upon the duration of the storm the aircraft either returned to Val d'Or for further refuelling or informed the Decca stations of a stand-down period and returned to Uplands.

Work in preparation for this project started in April 1959. The aircraft was received on May 22 and the installations of equipment were completed and test flown on July 7. The Decca ground network, major components of which were obtained on loan from the Department of Mines and Technical Surveys and the Royal Canadian Navy, came into operation on July 24 and the first seeding flight over the region was made on August 2. In eight weeks the aircraft was flown for approximately 110 hours and carried out 15 operations. The information and experience gained during these relatively short trials will serve as a valuable guide in planning the more protracted operations scheduled for the summer months during the next four years.

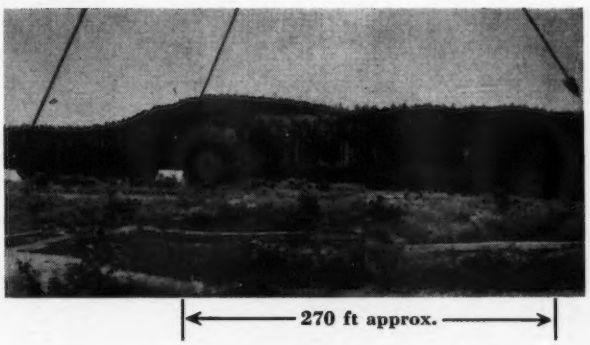


Figure 5
Composite photograph of the Red Slave Decca Station at Emerald Lake, Ontario

PARACHUTES, AND THEIR GROWTH†

by C. Bonn*

Irvin Air Chute, Limited

INTRODUCTION

THE idea for a parachute was conceived by Leonardo da Vinci in the fifteenth century. However, progress in its development was very slow.

Prior to World War I the parachute was generally used to provide thrills at public gatherings.

At the start of World War I both sides adopted the parachute to save the lives of balloon observers who were being shot down by manned airplanes. Soon the pilots of heavier-than-air craft adopted the parachute, a seat type, which was opened by means of a static line attached to the fuselage with the parachute being pulled from its container by the action of the pilot's body falling away from the aircraft. Shortly after the close of World War I the manually operated, or free fall, parachute was developed and adopted.

The modern parachute of today is a device of many uses varying from life saving to lowering troops, guiding torpedoes, lowering food, ammunition, cannons, jeeps, tanks and loads in ever increasing weights.

The application and use of the parachute is unlimited and its full potential remains to be explored.

PARACHUTE COMPLEXITY

The parachute has become more complex with the passing of the years and what was once a device for saving the lives of aeronauts and then later the lives of aviators now stands on the threshold of its greatest achievement, to save the lives of the astronauts. The parachute has actually become a useful device for a great variety of applications. It is used to decelerate aircraft in flight, to act as a brake after landing touchdown to reduce roll, recover missiles, missile components and target vehicles. As a matter of fact, parachutes are used to recover or facilitate recovery of almost everything that flies, and even some things that do not fly.

The drag and stabilization of high speed racing automobiles is one of the more recent unique uses of the parachute, and a recent inquiry has been made to determine the feasibility of utilizing drag parachutes on high speed water racing craft.

The design and construction of early parachutes were somewhat simple in approach, and they were fabricated of materials that were readily available. Although the theory for the design and construction differed between the early parachute experts, the basic concept remained significantly the same until the advent of speed. Complexity was injected by reason of the problems generated by speed and, although these problems up to that time pertained to the parachute as a direct life saving device, the importance of parachutes as an indirect life saving device took on added significance. This type of application consisted of deceleration and drag parachutes on aircraft, and cargo and resupply parachutes, which acted indirectly as life saving devices.

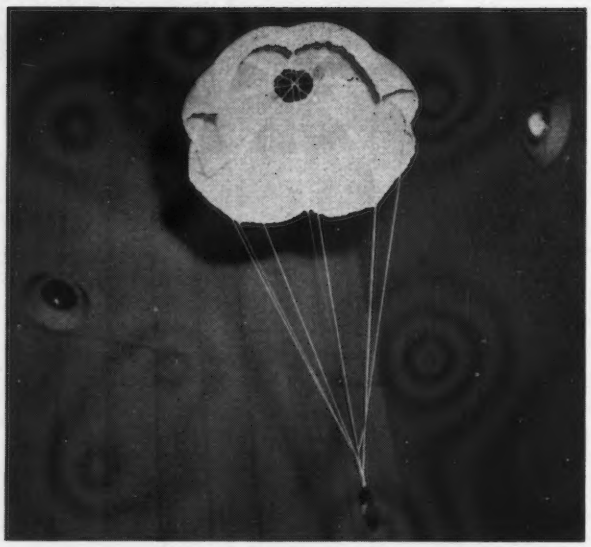


Figure 1

EARLY DESIGN PROGRESS

By reason of the fact that parachutes had taken on such a versatile outlook, all kinds of uses were conceived and tried. The more successful these attempts were, the more the parachute was turned to as a means to accomplish the endless tasks not easily solvable by other means. It was used to recover aircraft from spin tests if the aircraft failed to respond conventionally, to stabilize ejection seats or as a boom assist on flying tankers during refueling operations. "Necessity is the Mother of Invention", and it played no small part in parachute development and application. As rapidly as problems arose, people with parachute experience delved into the state-of-the-art in an effort to find a solution. Answers were sometimes laboriously arrived at by trial and error, but valuable information was obtained and the art of parachutes was advanced a little more each time. Scale model parachutes were used for study to reduce costs and avoid

†Received 18th January, 1960.

*Vice-President and General Manager.

the time consuming construction of full scale models during initial design studies. Figure 1 shows such a model being dropped in a tower for performance analysis. Requirements that were generated by World War II focused attention on the lack of parachute progress – progress that lagged seriously behind the progress of the aircraft. It was found that the flight personnel could not hope to save themselves with the parachutes that were being furnished, much less exit safely from these fast aircraft. The ejection seat was developed to provide a safe means of escape from fast aircraft and, almost immediately, became obsolescent by reason of the speeds of the latest aircraft.

PILOT PROTECTION

Necessity demanded consideration for improved or new methods or devices for pilot protection. Considerable progress had been made in Germany during World War II in the theory and development of protective devices and techniques. In addition to ejection seat work, a theory was advanced by the experts in the Stuttgart Institute in Germany that the cockpit area should be reinforced to provide protection for the pilot. They called this portion of the aircraft the "Citadel of Safety". They believed this area could be fortified to protect the pilot during the rigors of separation from the aircraft itself and during deceleration from high speed flight.

Protection could also be more easily and positively assured against temperature extremes and anoxia. There was even the sincere belief that this would provide adequate protection in crash landings. While the escape capsule concept of today falls markedly short of the original theory, the practicality nevertheless is in evidence by the protection it affords. Crash landing protection could possibly be provided but the weight penalty on the aircraft would be prohibitive. Circumvention of such shortcomings can sometimes be successfully made by the development of techniques and other devices for safe recovery of the pilot. This is a never ending task, and constant engineering and testing is done to provide even minute progress.

MATERIALS FOR PARACHUTES

Materials used in the fabrication of parachutes have been subjected to close study and, although significant material progress has been made, the benefit to parachutes, so far as the ability to withstand high speeds is concerned, has been limited.

Cotton, silk, nylon, dacron, fortison, viscose rayon, orlon, linen, glass polyethylene and even leather have been used in the manufacture of parachutes in one way or another from time to time. The predominant material in the industry today, however, is nylon. This material provides the most advantages with the least disadvantages over other materials available today, and is the major contributing factor to the high performance of our present day parachutes. Strength to weight ratio of nylon fabric is very high. For example, rip-stop nylon fabric, which is used as a standard material for man carrying canopy construction and which weighs approximately 1.1 ozs/sq yd, requires as much as 50 lb/in to break. When used in the manufacture of a parachute 28 ft in diameter and of typical design and construction, it will satisfactorily arrest a load of 200 lb moving at a velocity of 315 mph. This would be equal to a force of approximately 5,000 lb imposed on the arrested load. The great strength of nylon, together with its controlled elasticity, when properly formed into the latest design of parachute, exhibits ability to readily and consistently withstand these tremendous forces generated by the action of speed and weight.

DESIGN INNOVATIONS AND PARACHUTE ACCESSORY

The early parachutes were solid textile type canopies. But as parachutes were subjected to higher forces and stresses, ways and means of venting and methods for varying opening times were developed in an effort to relieve these destructive forces. The theory being that if the material could not be realistically and practically strengthened to withstand these forces, then circumvention by manipulation of design would be necessary.

From these theories evolved a variety of canopy designs and accessories to accomplish two things in general. One was to relieve internal canopy pressures by voiding air from the canopy under controlled methods and the other was to regulate canopy fill time, thus using time to effect deceleration to a safe speed for canopy inflation. Some of the methods that were tried for relieving internal canopy pressure consisted of enlarging the conventional vent at the apex of the canopy, placing additional vents strategically throughout the canopy, using ribbon in the construction of the canopy with regulated spaces between the ribbons and using defined widths of fabric formed in a concentric pattern with regulated concentric spacings.

Some of the methods that were tried to regulate canopy fill time consisted of automatic force reefing, mechanical reefing and skirt spoilers.

The automatic force reefing consisted of a mechanical sensing device which disreefed the parachute according to the decay of the forces felt by the parachute.

The mechanical reefing consisted of a line of predetermined size and length passed through metal rings successively secured to the skirt of the canopy and secured together to form a continuous loop. This restricted the opening of the canopy skirt to a desired dimension and then, upon a predetermined time after initiation of the parachute system, a pyrotechnic device, which was secured to the canopy skirt band with the reefing line passed through it, delivered energy to sever the line by burning or by a guillotine blade. The canopy could then assume its full designed diameter, but with less opening force, due to deceleration through delay in fully opening.

The skirt spoilers consisted of several designs, but the principal in all was to present a reverse airfoil which caused an air deflection at the skirt and reduced air volume for filling.

All of these theories enjoyed varying degrees of success. Some have become the mainstay of parachute design and operation and are essential to the phemonenal accomplishments of parachutes of the present day.

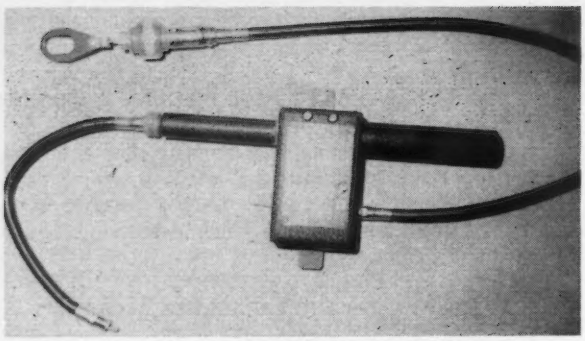


Figure 2
Barometric automatic opener

DELAY MECHANISMS

Considerable progress has been made, for instance, in the protection of aircrew against the effects of anoxia and low temperatures by the use of automatic release mechanisms. These are installed inside the parachute pack and assure that the pilot descends, after bailout, to a safe altitude by free fall in the shortest possible time. At this safe altitude the parachute ripcord pins are forcibly extracted by the mechanism either by coil spring or pyrotechnic means.

A combination of barometric capsule and/or mechanical timer is used as the prime mover depending upon altitude. The choice is selected automatically by the mechanism so that irrespective of whether the pilot is travelling at high velocity at 60,000 ft or low velocity at 6,000 ft he can be assured of protection. In Figure 2 is shown a barometric automatic opener presently in service use.

RATES OF DESCENT

The rate at which a parachute descends at ground level is a function of the weight that is suspended and the parachute effective drag area. Design of the various types of canopies, therefore, is entirely dependent upon the desired rate of descent. Whereas it may be quite permissible to have an item of equipment land with a vertical rate of 50 ft/sec there are strict limits applied to the rate at which human beings can land without injury. The fine shade of difference depends upon the parachute's function. In premeditated descents such as forest fire fighting personnel, paratroops and such, where bulk and weight is of no consequence, large canopies up to 35 ft in diameter are used which give rates of descent in the region of 15-18 ft/sec. On the other hand, in an aircraft escape system where space and weight is of paramount importance the canopy generally is 24 ft in diameter, which naturally gives a higher, but still safe, vertical descent rate.

It was mentioned earlier that the uses of a parachute would seem unlimited. In Figure 3 is shown the rate of descent vs canopy loading for a wide variety of parachute types and functions.

In many cases it is possible for the load to assist the parachute in its function. In the dropping of heavy cargos, a wide variety of shock absorbing materials is used ranging from honeycombed paperboard to air-bags and nose spikes.

In Figures 4 and 5 the development sequence of the recovery parachute system of a missile is shown. It will be seen that two distinct types of landing assist are used; in Figure 4, additional g load absorption is effected by a nose landing spike, whereas in Figure 5 air bags are used.

CARGO PARACHUTES

Parachutes have also been designed as so-called work horses and, experimentally, have reached as much as 200 ft in diameter. Cargo requirements are extensive and a variety of types and sizes have been designed. In most instances, the design of parachute equipment is based on getting the cargo to the ground in the least possible time without damage, applying the most economical and practical methods. Generally, there are four types of parachute canopies used for aerial delivery systems; the standard flat, the hemispherical, the full extended skirt and the conical type. Sizes range from 8 ft in diameter to 100 ft in diameter. The 100 ft parachute weighs 240 lb and has a carrying capacity of 3,500 lb. However, when used in cluster – several canopies assembled to provide resistance to the load simultaneously – the carrying capacity is increased to as much as 25,000 lb. Techniques for transporting in aircraft and effecting drops have been developed, modified and re-modified, until cargo can be carried and pin-point dropped in a minimum of time. The limitations for dropping cargo, generally, can be relegated to the limitations imposed by the carrying capacity of the aircraft.

While the dropping of cargo is as old as flying and parachutes themselves, the significant progress of the art was made during World War II and since that time.

In this field the future of design, development and use of parachutes is unlimited and promises to provide good furtherance of parachutes.

GUIDED MISSILE PARACHUTES

Generally, parachutes for guided missiles must be individually tailored for each application. As applied, they usually consist of several components and are referred to as a recovery system. Arriving at such a system consists of establishing the over-all design of the recovery

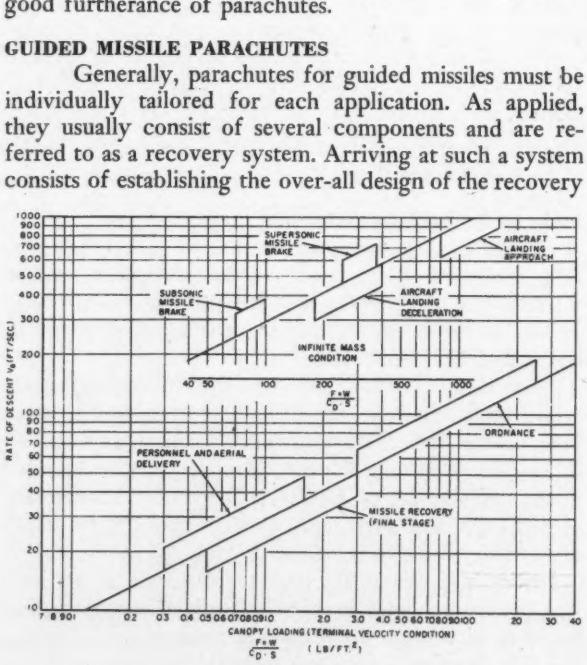


Figure 3
Rate of descent vs parachute canopy loading for terminal velocity conditions

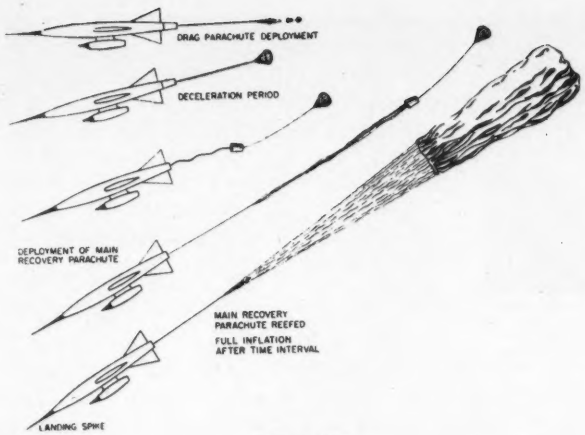


Figure 4
Landing assist — spike

system, establishing the detailed design of the respective stages and components, and fabrication and qualification testing of the resulting components and systems.

Since recovery of the missile, or a component of it, usually involves extreme speed and even great altitude, the problems of recovery become tremendous. Speed presents problems of heat and high shock force and high altitude presents inherent problems of low temperature acting on the system prior to initiation and low density atmosphere after initiation.

Consequently, design considerations must include these factors, and design results must provide for combating them where possible or circumventing them when no other recourse is available.

Quite frequently the problem of recovery necessarily imposes restrictions of g limitation on the vehicle or component and, therefore, requires a gradual imposition of forces by the parachute to effect reduction in velocity. Since tumbling and erratic flight behaviour can be expected to take place on an unstabilized component, the application of a small first stage parachute serves the purpose of a stabilizing device as well as accomplishing deceleration.

Since maximum deceleration over the shortest flight path requires a constant application of the maximum

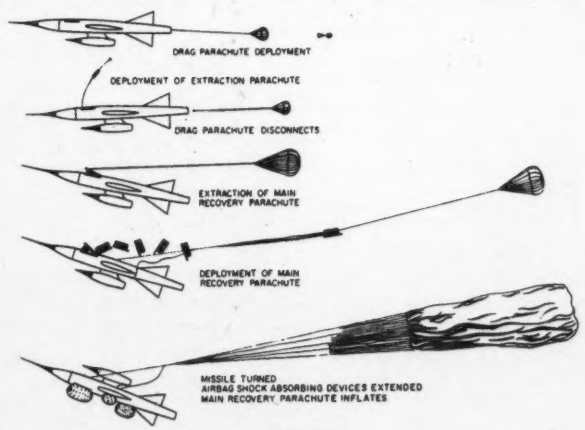


Figure 5
Landing assist — air bags

allowable forces on the vehicle being recovered, several stages of applied force become necessary. But with the addition of each stage, the weight and volume of the recovery system tends to become prohibitive. When this situation arises, the force application required can be obtained by providing a lesser number of parachutes in the system, and then reefing one or more of the parachutes in the system, with one or more reefed diameters applied for a predetermined time. In this way a maximum g force can be applied without exceeding the maximum g force allowed, and thereby the deceleration of the vehicle can be effected in a minimum of time. Figure 6 shows a typical force versus time curve for a missile recovery parachute system. The imposition of various stages, both parachute and reefing, are clearly indicated by forcetime changes.

Arresting the missile or component in flight is only part of the recovery problem and delivery back to earth is fraught with problems, both on land and in water.

If a water landing is planned, an automatic disconnect of the recovery parachute is necessary after touch-down, to avoid dragging; a flotation system to maintain the recovered vehicle afloat; a marker system for both visual and non-visual location and a means for repelling sharks to avoid rupture of the flotation bags.

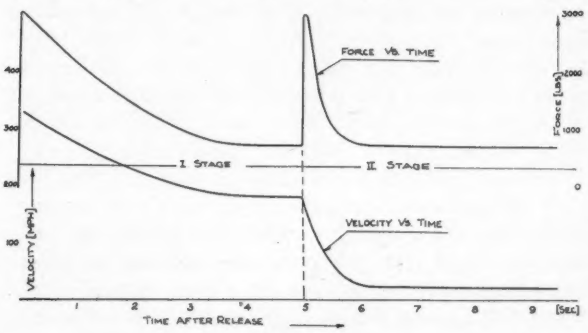


Figure 6
Force and velocity vs time

Conversely, if a landing is planned on land, the problems are in many respects different, although an automatic disconnect device is required after touchdown to avoid dragging; the forces imposed on the recovered vehicle by landing on firm ground sometimes become intolerable and measures must be taken to relieve these conditions. If it is proposed to land the vehicle in a horizontal plane, and the weight and volume allowances for the parachute system prohibit a sufficiently large system to provide for an acceptable landing velocity, air bags can be employed to reduce the landing shock. These bags are inflated by the initiation of the parachute system and are so arranged that they are punctured on landing to effectively reduce the landing impact.

If the vehicle is so designed that it may be landed vertically, a nose spike arrangement can be made, whereby landing impact can be reduced by ground penetration. In this case, a landing velocity of 50 ft to 70 ft/sec is desirable for good nose spike ground penetration and, therefore, the parachute can be even smaller than that for a horizontal landing attitude, all other factors being constant.

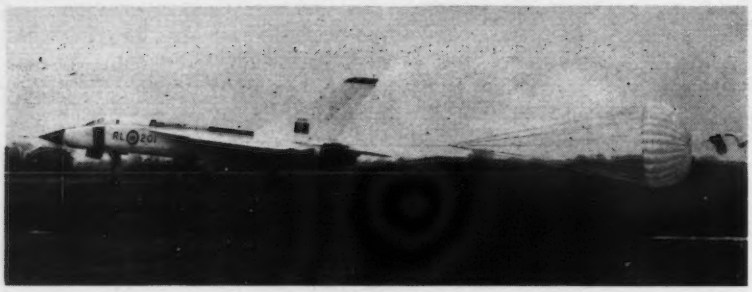


Figure 7
Drag parachutes in operation

AIRCRAFT DRAG PARACHUTES

There are three general applications for parachutes under the broad heading of "Aircraft Drag Parachutes". These are aircraft in-flight emergency deceleration parachutes, aircraft landing approach control parachutes and aircraft landing roll control parachutes.

In-flight emergency parachutes are usually installed in prototype aircraft where conventional bailout is not practicable and yet ejection seats are not provided. Jet type commercial aircraft are typical examples.

In the event the aircraft should develop flutter during flight trials, the parachute can be used to effect rapid deceleration from the speed range which induced the flutter condition and then be jettisoned so that a normal landing can be made; and, of course, if structural failure of the aircraft occurs, the rapid deceleration to a safe bailout speed facilitates a timely escape of the crew.

If the parachute is designed to allow for landing approach and landing roll control, it is possible to continue the flight with the parachute streamed to allow for landing on short runways, or in small landing areas.

Landing approach control parachutes permit descents with more engine power maintained than would be possible for the aircraft otherwise. Safety is increased by the application of the parachute in this manner. These parachutes are used both in prototype and production aircraft.

Landing roll control parachutes are intended to be used as an auxiliary to mechanical braking devices in order to effectively reduce aircraft landing roll. Figure 7 shows a typical drag parachute in operation. This type of parachute application has been instrumental, at least in part, in making it possible to further aircraft performance by satisfactorily controlling aircraft landing roll. It is a very economical method for coping with the problems attendant to landing a fast aircraft on the majority of air fields. If the control of landing roll were left to conventional wheel brakes, super airports with runways of excessive lengths would be required to handle a great number of modern aircraft.

It may be of interest to know that the use of parachutes to reduce the landing roll of aircraft is not new. Actually, records show that a parachute was used for this purpose as early as 1923. Figure 8 shows a typical example of braking force using wheel brakes and drag parachutes.

MODERN MAN CARRYING PARACHUTES

Man carrying parachutes have been designed, modified and re-modified over the years but the new sport of "Sky Diving" has engendered many novel ideas in parachute design. While most of these ideas encompass the canopy only, the harness, container and their respective components have been somewhat modified.

Changes in equipment design have been with a view to furthering the advantages of the individual application and, since steering or maneuvering the canopy to a landing at a predetermined spot is the prime object of the Sky-Diver, steerability of the canopy is the foremost consideration.

A canopy which forms a polygon will descend in a theoretically vertical descent and will generally only deviate from this course by the movement of air currents. Thus the drift of a conventional canopy is reduced to a minimum if wind velocities are essentially light.

Since premeditated parachute jumping is only practiced in wind velocities of twelve knots or less, a self generated drift becomes desirable to facilitate "spot" landings.

By installing strategically placed reinforced holes in the canopy to create a jet flow of air in a horizontal fashion, the glide rate of the parachute is effectively increased.

This type of innovation, while employed primarily in sport jumping, is also used for specialized application in rescue work and fire fighting in inaccessible areas. It can also be used in any case where self generated drift is desirable. Figure 9 shows a parachute with a hole installed to facilitate steerability and glide.

The man carrying parachute that is used essentially for emergency life saving purposes has not undergone the numerous changes that its counterpart the sport parachute has.

Steering and manipulation of the parachute during descent requires some training and jumping experience

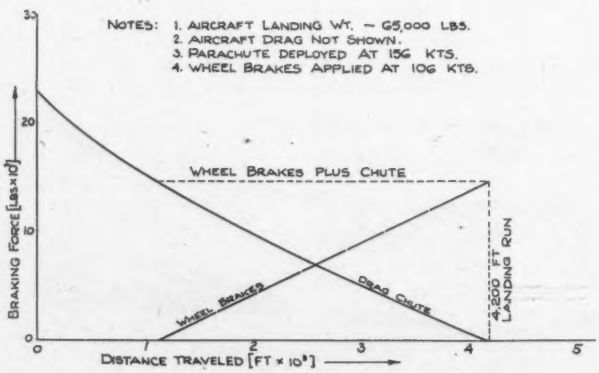


Figure 8
Braking force during landing run for aircraft using wheel brakes and chute

Figure 9
Steerable parachute inflated and descending

Figure 10
Extended skirt parachute inflated and descending

to perform well and, since the aviator usually does not possess this experience, it is better that the parachute which he wears be designed to serve only as the "Life Preserver of the Air".

This parachute is designed and manufactured with the view that it must stand ready to save the airman's life, regardless of circumstances. Reliability is the foremost consideration and it applies to both operational and structural integrity.

Weight and bulk is always a consideration in parachute design. Maximum protection must be provided with a minimum of space consumption. As an example, a 28 ft diameter canopy occupies a space of less than 1,000 cu in and, when installed in a back type configuration, together with all its components and fittings, including the barometric release device, it weighs less than 30 lb.

Parachutes receive special consideration when used for paratrooper application. Since this is a highly specialized field, special attention is given to the design of the canopy as well as the design of the container and harness.

A slow rate of descent, free of oscillations, is desired. The extended skirt design, which has a flat circular center and an annular ring in the form of an inverted truncated cone added, in a 35 ft diameter size, as shown in Figure 10, has been selected for paratrooper use since it most nearly approximates the desired performance. The container is designed to be opened by a static line and the harness is designed to allow for quick doffing after landing.

The outstanding record of safety and reliability, amassed during thousands of jumps accomplished with this equipment, attests to the integrity of the design.

CONCLUSION

While the idea of the parachute was conceived in the fifteenth century, and remained latent for over four hundred years, the significant progress with this device has been in our life time. The potential has not been fully recognized even today, and it appears to be a certainty that the parachute will be an essential piece of equipment in the exploration of outer space.

The history of the parachute of the future will only be written by history itself.

XIth INTERNATIONAL ASTRONAUTICAL CONFERENCE

Stockholm, Sweden: 15th-20th August, 1960

THE Swedish Interplanetary Society will be the host to the XIth International Astronautical Congress, which will be held by the International Astronautical Federation in August. The meetings will take place in the Royal Institute of Technology, Stockholm.

A list of the topics to be discussed has been issued, and the submission of papers invited, though no programme has yet been prepared. These topics are listed below and, in addition, it is understood that the Symposia on Space-Medicine and Space-Law will be held during the Congress.

Basic Sciences

Planetary Atmosphere Environments: Basic atmospheric properties; Physical and chemical problems of atmospheric flight (e.g. re-entry).

Interplanetary Space: Interplanetary matter and radiation; Planetary magnetic fields, particle belts, etc.

Space Medicine and Biology: Physiological and psychological aspects of life in extraterrestial environments.

Navigation, Guidance and Control, Space Communication

Trajectories: Powered and free flight in space and within planetary atmospheres.

Propulsion: Present and future systems.

Vehicles: General systems concepts, subsystems, structures, materials, equipment, power supply, assembly in space etc.

Space Probes, Satellites, High Altitude Rockets: Specified projects—descriptions and presentation of results.

Economical Factors: Economics and planning of space research, technology and development.

INFORMATION

Further information can be obtained from IAF-60, Box 5045, Stockholm 5, Sweden.

SECOND INTERNATIONAL CONGRESS IN THE AERONAUTICAL SCIENCES

Zurich, Switzerland: 12th-16th September, 1960

THE International Council of the Aeronautical Sciences (I.C.A.S.) was formed in 1956 and its First Congress was held in Madrid, Spain, in September 1958. The Second Congress will be held in Zurich, Switzerland, from the 12th to the 16th September 1960. The twenty-four participating countries are Argentina, Australia, Belgium, Brazil, Canada, Denmark, France, Germany, Israel, Italy, Japan, Netherlands, New Zealand, Poland, Rumania, South Africa, Spain, Sweden, Switzerland, Turkey, Union of Soviet Socialist Republics, United Kingdom, United States of America, Yugoslavia; Canada is represented by the C.A.I.

The programme has not yet been settled in detail but the subjects to be covered are listed below. In addition, the programme will include the Daniel and Florence Guggenheim International Memorial Lecture to be presented by Professor Jakob Ackeret of Switzerland on "Concept of Entropy in the Development of Aero Space Sciences".

Aerodynamics: Boundary layer transition in subsonic flow; Shock wave boundary layer interference in supersonic flow; Three-dimensional boundary layer theory; Aerodynamic design of wings and bodies, and related flow problems; Non-stationary transonic flow; Slip flow phenomena in rarefied gases.

Heat: Heat transfer involving transfer of matter; Heat sources and sinks.

Aerothermochemistry: Theory of laminar and turbulent flame propagation; Combustion of solid propellants; Instability in solid and liquid rockets; Flow with chemical reactions.

Magnetohydrodynamics: Dissociation and ionization effects in hypersonic flows.

Aeroelasticity: Aerothermal effects including high speed flutter.

Fatigue: Theory of fatigue; Fatigue of aircraft structures.

Materials: Stress corrosion; Protection of aircraft structures against corrosion and high temperature.

Flight Mechanics and Guidance in Upper Atmopshere and Space: Speed and altitude limits for air breathing engines; Controllable propulsion devices for missiles and space vehicles; Use of power sources available in space; Methods and limitations for the mutual communication between atmospheric or space vehicles and communication with the ground; Limiting factors for the accuracy of guidance in various actual devices; Deductions from observation of satellite orbits.

Aero and Space Medicine: Recent progress in aero and space medicine; Human limitations and their influence on the design of aero and space vehicles.

Relations between Economic and Technical Aspects of Air Transport: Relative importance of technical factors on economy of transportation based on recent experiences with conventional turboprop and jet aircraft; Influence of the shortening of takeoff and landing distances on the economic exploitation of various STOL-VTOL aircraft.

INFORMATION

Canadians wishing to attend the meeting, whether members of the C.A.I. or not, should apply to the Secretary C.A.I. for application forms and further information.

C.A.I. LOG

SECRETARY'S LETTER

COMING EVENTS

In the December issue of the Journal we introduced a "Coming Events" section, giving particulars of a few future meetings which might be of interest to our members. Several people have told me that they have found this information useful and I hope that we shall be able to increase the listing as we go on.

From time to time some of our members who travel a lot have asked to be put on the mailing lists of all the Branches, so that they will get copies of all meeting notices; sometimes their wanderings would enable them to attend meetings of Branches other than their own, if only they knew about them in advance. It is impracticable, for a number of reasons, to grant these requests but an effective advance listing in the Journal would serve the purpose.

In each listing we give particulars of all Branch meetings to be held in the next two months – whenever we know enough particulars to make an entry worthwhile. I appreciate that Branches often have great difficulty in establishing, with any degree of certainty, all the essential features of their meetings several months in advance; and, of course, for publication in the Journal, we need a little lead time too. But I have asked the Branch Secretaries to do their best and I hope that by our combined efforts we shall be able to render a useful service.

In addition to Branch meetings, I should like to list other meetings whenever the essential features – date, time, place, subject and speaker – are available, and I would ask all our members to let me know of technical meetings on aeronautical subjects which may come to their attention. Mr. Soucy and Professor Newman have already helped us by submitting details of the IRE/ASQC/EIA/AIEE Symposium and the McGill University series of lectures, respectively.

ANNUAL DUES

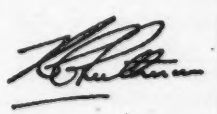
Dues bills are being sent out this month; the fiscal year of the Institute begins on the 1st April. There is a sort of period of grace between now and the beginning of October, after which members who have not paid their dues become technically "in arrears". The Branches are financed on the basis of the numbers of their members in good standing on the 1st October and so, in the interests of their own Branches, members are asked to pay their dues before the distractions (and expenses) of the summer holidays put all thought of the C.A.I. out of their heads.

TORONTO

The President and I have been on our travels again; this time we visited Toronto – twice. The first time was for the purposes of a joint meeting of the Institute's Executive and Planning Committees, on the 12th February, and the second to attend the Branch Student Thesis Night on the 16th. The latter date fitted in nicely with our trip to Edmonton for the Mid-season Meeting; we simply continued our journey the next day.

The Toronto Thesis Night was great fun. On our arrival at Malton we were met by Dr. Wade and taken to dinner with the Branch Officers, the competing Students and the panel of judges, and then we proceeded to the Institute of Aerophysics where the meeting was to be held. They do things well in Toronto and, though the attendance was not as good as it might have been, the meeting went with a swing, with never a dull moment. The topics ranged from air-cushion principles to snitching moons from Jupiter and the whole thing demonstrated not only considerable ability among our Students but a wisdom in our panel of judges that would have been a credit to Solomon.

There is neither time nor space to comment on the Mid-season Meeting. We will report on that next month. I will just say now that it was an outstanding success.



ANNUAL GENERAL MEETING

CHATEAU LAURIER

OTTAWA

24th and 25th May, 1960

24th May	Morning	– 9.00 a.m. to 10.30 a.m. . . .	Business Meeting
	Morning	– 10.45 a.m. to 12.30 p.m. . . .	Man in Space
	Afternoon	– 2.30 p.m. to 5.00 p.m. . . .	Honours and Awards and the W. Rupert Turnbull Lecture
	Evening	– 7.00 p.m.	Dinner
25th May	Morning	– 9.00 a.m. to 12.00 noon . . .	Air Transportation
	Morning	– 9.00 a.m. to 10.30 a.m. . . .	Astronautics Section*
	Morning	– 10.45 a.m. to 12.00 noon . . .	Propulsion Section*
	Afternoon	– 2.00 p.m. to 5.00 p.m. . . .	Industrial
	Afternoon	– 2.00 p.m. to 5.00 p.m. . . .	Test Pilots Section*

*Section Annual General Meeting

BRITISH INCOME TAX

The Canadian Aeronautical Institute has been approved for the purposes of Section 16 of the British Finance Act 1958. Members who qualify for relief under that Section will be allowed to deduct the whole of their annual dues from their emoluments assessable to income tax under Schedule E.

The following is an extract from the letter of approval:

"Commencing with the year to 5 April 1959, a member who is assessable to income tax under Schedule E in respect of the emoluments of an office or employment is entitled to a deduction from those emoluments of the whole of the annual subscription which is due and payable to him to the society in the income tax year provided that –

(a) the subscription is defrayed out of the emoluments of the office or employment, and,

(b) the activities of the society so far as they are directed to all or any of the following objects –

(i) the advancement or spreading of knowledge (whether generally or among persons belonging to the same or similar professions or occupying the same or similar positions);

(ii) the maintenance or improvement of standards of conduct and competence among the members of any profession;

(iii) the idemnification or protection of members of any profession against claims in respect of liabilities incurred by them in the exercise of their profession;

are relevant to the office or employment, that is to say, the performance of the duties of the office or employment is directly affected by the knowledge concerned or involves the exercise of the profession concerned."

A member who is entitled to the relief should apply to his tax office as soon as possible for Form P358 on which to make a claim for the relief due to him.

H. C. LUTTMAN, *Secretary*.

BRANCHES

SURVEY OF THE BRANCHES

Winnipeg

By B. W. Torell
Chairman

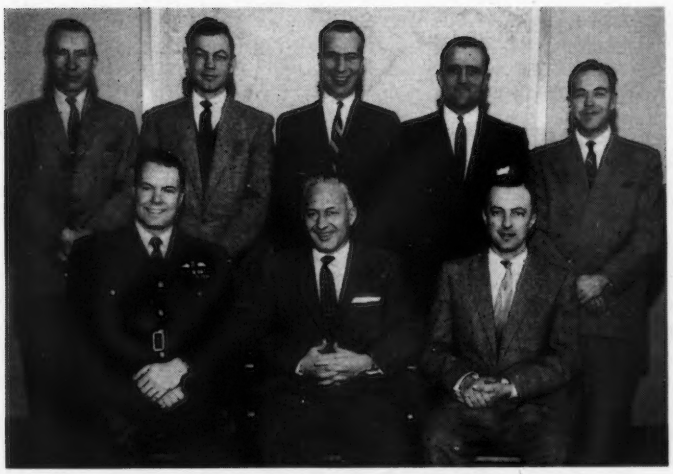
The first inclination for the initiation of a Winnipeg Branch of the Canadian Aeronautical Institute came in 1954 and, as a result of Headquarters becoming aware of this, an Interim Secretary was appointed in November, 1954. The person appointed to this job was Mr. R. T. Gibson who, at one time, was Secretary, Toronto Section, of the Institute of the Aeronautical Sciences. He had also been a keen supporter of the CAI in its formative stages. At this time, there were only nine CAI members in the Winnipeg area. An Interim Committee was set up consisting of: Mr. W. S. Haggett (Interim Chairman), Mr. R. H. May, Mr. W. E. Robinson, Mr. R. T. Gibson and Mr. B. W. Torell.

A formal application for the establishment of the Winnipeg Branch was made on April 5, 1955, and, upon reaching the necessary twenty members, formal approval was received April 16, 1955. An election was held and the first Executive consisted of: Mr. W. S. Haggett, Chairman; Mr. J. J. Eden, Vic-Chairman; Mr. R. T. Gibson, Secretary; Mr. C. M. Hovey, Treasurer; Mr. R. C. Guest, Councillor, and Mr. D. A. Newey, Councillor.

The inaugural meeting was held June 21, 1955 and consisted of a display of the Bristol "Sycamore" Helicopter and a Trans-Canada Airlines' Vickers Viscount. Following a dinner in the Bristol Room of the Airport Hotel, a Shell film, "Powered Flight" was shown. Chairmen in the succeeding years were: Mr. J. J. Eden (1956-57), Mr. C. M. Hovey (1957-58) and Mr. E. L. Bunnell (1958-59).

The present Executive of the Winnipeg Branch consists of: W/C J. C. Evans, Vice-Chairman; L. T. Deane, Treasurer; N. J. Thomas, Secretary; J. G. Davidson, Councillor; S. Sawyer, Chairman, Membership Committee; D. C. Marshall, Chairman, Program Committee, and E. W. Baker, Chairman, Social Committee. Our other Councillor, who at the present time is located in Ottawa, is F/L J. J. Deslauriers.

It was decided this year that the Chairmen of the Membership, Social and Program Committees should be full-fledged members of the Executive as the success of the Branch depends, to a considerable degree, on their activities.



Winnipeg Branch Executive
Standing (l to r): Mr. E. W. Baker, Mr. D. C. Marshall, Mr. J. G. Davidson, Mr. L. T. Deane and Mr. S. Sawyer
Sitting (l to r): W/C J. C. Evans, Mr. B. W. Torell and Mr. N. J. Thomas

The Executive Committee which meets the second Tuesday in each month guides the activities of the Branch as a whole. It sets the objectives for the Branch, within the general framework of the over-all objectives of the Institute, and for the specific Committees for the year. It reviews the plans made to achieve these objectives and the results through the implementation of these plans, making adjustments to the plans as necessary.

The membership of the Winnipeg Branch grew rapidly in the beginning. In April, 1955, we had 20 members; by May, 1956, it had increased to 92. May, 1957, saw a membership of 112 with a figure of 117 by May, 1958. May, 1959, saw only two additional members being added and at the present time we have 121 members in good standing.

From the above, it would appear that in the last several years the Branch has been fairly stagnant. These figures do not tell the whole story however, as we have lost, roughly, 20 to 25 members per year as a result of resignations and transfers.

The Winnipeg membership represents over fifteen local aeronautical concerns in the Winnipeg area, such as Transair, Department of Transport, Parsons Airways Ltd., The Winnipeg Flying Club, etc, with the majority of the members belonging to Bristol Aircraft Limited, Standard Aero Engine Limited, Trans-Canada Air Lines and the RCAF. With the recent transfer of the RCAF Training Command to the Winnipeg area, it is felt that there is a considerable potential for additional members. Another source of membership that is being actively pursued is the University of Manitoba.

The Branch activities consist, generally, of ten meetings which are designed to further the objectives of the Canadian Aeronautical Institute. These are, consistently, dinner type lecture meetings with the exception of a dance held once each year. Our dinner meetings are held on the Winnipeg Flying Club premises.

The Membership Committee Chairman, Mr. H. S. Sawyer, has objectives of (a) increasing the membership to 175; (b) reducing resignations by 50% during the 1959-60 term and (c) achieving an attendance of 80 members and guests at all meetings. Only time will tell if he is able to achieve the first two objectives. The third has not been reached yet but attendance has been highly satisfactory with, roughly, 50% of our membership attending every meeting.

The Chairman of the Social Committee, Mr. E. W. Baker, has, in addition

to his normal chores of arranging for accommodation, selling of tickets etc, had the responsibility of publicizing our meetings through the medium of press, radio and television. To date he has been most successful, mainly in the area of press publicity. Another of his objectives was to achieve a 5% profit on all social events. He may be successful in accomplishing this objective but precedence is decidedly against him.

Our Program Committee Chairman, Mr. D. C. Marshall, is in charge of all aspects of recommending and arranging for the speakers.

We, in Winnipeg, are very fortunate as a result of our environment in that (a) the climate eliminates all the weaker types of humans and leaves us only the strongest and best for CAI membership, and (b) Winnipeg being so far from Head Office, when we request a speaker from major companies, only the top men, sufficiently high in the organizations' structure, are able to obtain top management approval for travelling the distance involved. We are not at all complacent as a result of this desirable situation and, occasionally, we go so far as to pity some of the other Branches, such as Montreal and Toronto, who are not in such fortunate circumstances.

We hold our Executive meetings the second Tuesday in each month and our Branch meetings the fourth Tuesday in each month. The program for the rest of the year is as follows: March – Mr. Fia, Bristol Aero Industries, "Missiles"; April – A speaker from Rolls-Royce, Derby, England, "The Development of the Tyne Engine"; May – Dr. P. J. Sandiford, Director of Operations Research, "Truth Without Consequences"; June – Annual Meeting – Speaker not chosen as yet.

We believe that we as a Branch have come a long way over the past four years and that we still have a long way to go. The future, however, holds no fears as a result of the excellent calibre of the membership and their deep interest in the CAI. We also believe that the Winnipeg Branch as well as the Institute as a whole is only in its embryo stages as is the use of the aerodyne as a mass transportation medium. Along with the technical advances made in the aviation industry will come the gradual elimination of surface transportation. Certainly within our lifetime we will see the elimination of the surface transport of humans. The next generation will probably see the elimination of surface transport of manufactured goods and possibly certain low bulk raw materials. We predict that the membership of the Winnipeg Branch of the Canadian Aeronautical Institute will reach 2,000 by the year 2000 AD.

Vancouver

By J. R. Hutton
Chairman

Looking back through the official records of the Vancouver Branch, the first indications of interest in forming a Branch are found in correspondence dated August, 1954. Formal approval of the establishment of a Branch was given by the Council in January, 1955, and after election of an Executive Committee the first technical meeting was held on March 17th, 1955. The speaker on this occasion was Captain J. L. Pritchard, C.B.E., Hon. Fellow R.Ae.S. (Past Secretary of the Royal Aeronautical Society), who spoke on Aviation History. An auspicious start to any Branch.

At this time there were approximately 50 members in the area with all but a few located in organizations at Vancouver Airport. The Branch membership has grown through the years to the present strength of 140 members, and has expanded in area to include industries associated with aviation in Greater Vancouver, Vancouver Island and Seattle, Washington. This growth is encouraging when it is considered that the aviation industry in British Columbia is associated entirely with scheduled airline operation, chartered aircraft, helicopter operation and service and overhaul facilities.

The first Executive Committee comprised Mr. H. D. Cameron, Chairman; Mr. E. N. Atkey, Vice-Chairman; Mr. R. J. McWilliams, Secretary-Treasurer; with Messrs. T. W. Siers and J. Bertalino as our first Councillors. The sound policies formulated by this Executive and developed and maintained by successive Executive Committees and Councillors have contributed greatly to the success of the Branch.

A highlight of the Branch history to date was the Mid-season Meeting held in the Hotel Vancouver in 1958. Apart from the pleasure of hosting this well-attended meeting, it aroused considerable local enthusiasm, assisting our membership drive.

Recognizing that one of the primary, if not main, functions of the Branch is to develop a sound programme of technical meetings, every effort has been made during the years to provide a programme of technical meetings catering to the requirements of our local membership. Our programme runs from September to April with technical meetings being held at the Officers' Mess, RCAF Station Sea Island, with the exception of one dinner meeting in the fall session and a joint SAE/CAI dinner meeting in the spring session. To cater for the ladies a social meeting is held during the fall session and the Annual General Meeting is followed by a dinner and dance.

Some idea of our programme can be gathered from typical meetings held during the 1959-60 season, such as:

"Design Aspects of the Supersonic Transport" by L. T. Goodmanson of Boeing Aircraft Ltd.

"Science and the Space Age" by Dr. G. M. Shrum, Dean of the Faculty of Graduate Studies, University of British Columbia.

Panel Discussion on By-Pass and Turbo Fan Engines by representatives of Rolls-Royce, Pratt & Whitney and General Electric.

An active Student Section currently caters to students at the Canadian Services College, Royal Roads, Victoria.

Vancouver Branch Executive

(Standing l to r): Mr. H. G. Packer, Mr. W. K. Rutledge, Mr. L. C. Bryan, Mr. G. W. T. Roper and S/L A. E. Falls

(Sitting l to r): Mr. J. W. Whiskin, Mr. F. L. Hartley, Mr. J. R. S. Hutton, Mr. R. J. McWilliams and Mr. W. R. Higgins

The Branch provides the Student Section with guidance in their affairs and assistance in programme planning. Considering the demands on student time in their normal curriculum, the formation and continued activity of this Section is most encouraging. A student essay competition is sponsored by the Branch. Negotiations in an endeavour to establish a Student Section at UBC are currently under way.

Dealing generally with the problem of increasing our membership and promoting larger attendances at our meetings, a system of block captains under the Chairman of our Membership Committee was established this year. These block captains are drawn one from each major organization in the area, and their function is to form a personal contact between the Executive and members and potential members in their respective organizations. Through this system it is hoped to promote additional members and publicize forthcoming Branch events.

The growth of the Vancouver Branch has been most encouraging and, while no effort is being spared for still further expansion, it is felt that the growth pattern will not be maintained at the past rate unless a major change in the aviation industry takes place in this area.

NEWS

Toronto

Reported by C. F. de Jersey
January Meeting

The fifth meeting of the Toronto Branch was held at the Institute of Aerophysics, University of Toronto on Thursday, 21st January, 1960.

After welcoming the audience of 62, Dr. J. H. T. Wade, the Branch Chairman, asked Prof. E. D. Poppleton of the UTIA to introduce the speaker for the evening, whose subject was "Fatigue".

Prof. Poppleton outlined the work Dr. Freudenthal is currently undertaking at Columbia University, New York, and told of his training in Prague and of his teaching assignments in places as far apart as Haifa and Illinois.

Dr. Freudenthal introduced his subject by outlining the areas about which he intended principally to speak. He presented the metal physics of problems, the validity of the cumulative damage rule and reliability function under fatigue and discrete load cases.

Structures should in all cases be designed for the probability of the limit load condition being reached but once in the calculated life span, and the designed ultimate load anticipated would then be determined as approximately 1.5 of this limit load.

Dr. Freudenthal mentioned that tests conducted at Columbia University revealed that the risk of failure does not remain static, but increases proportionally to the age of the structure concerned.

By using a series of excellent slides, the Speaker showed graphs depicting fatigue cycles versus probability of failure, by which the mean life and minimum life expectancy could be determined; photographic enlargements of electro-microscopic slides showing the formation of cracks in various metals, and further graphs illustrating that anticipated life is normally shorter than calculations utilizing the linear damage rule would indicate. Dr. Freudenthal stated that this latter theory was supported by tests conducted by others in the field, particularly by the Australian researchers.

Finally Dr. Freudenthal showed that preloading structures provides an increase in life expectancy by two to four times, dependent of course upon the percentage of preloading attained, and cited examples of this, especially in springs and crane hooks.

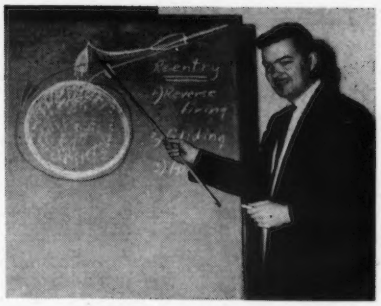
After a lively question period followed by a vote of thanks given by Mr. H. B. Dunthorne of Orenda Engines Limited, Dr. Wade closed the meeting by reminding the audience of the annual Student Thesis night, to be held this year on Tuesday, 16th February.

Halifax-Dartmouth

Reported by J. Milman
January Meeting

The January meeting of the Branch was held in the cinema of the Chief Petty Officers' Mess, HMCS Shearwater, on Wednesday, January 20, 1960. The Branch Chairman, Mr. R. Wallworth, was in the chair. 65 members and guests attended the meeting. Mr. Wallworth stated that the Branch was losing two of its more stalwart members in Mr. Cornelius, the Branch Treasurer, and Mr. M. C. Eames, both of whom were going to the USA. He introduced Mr. Bowers, who was taking over the post of Treasurer for the remainder of the year.

Mr. R. Wallworth making the presentation to CPO Batten



Prof. O. Cochkanoff

A silver tray and cocktail shaker was presented by the Chairman on behalf of the Branch to CPO Batten, Mess President of the Chief Petty Officers' Mess, in appreciation of the use of the mess by the Branch for meetings.

The speaker of the evening, Professor O. Cochkanoff of Nova Scotia Technical College was introduced by Mr. Garrard who pointed out that Professor Cochkanoff had recently returned from a course at Iowa State University during which he had worked on missile problems relating to thermal stresses in plates and sloshing of fuels in tanks. Also, he had recently visited Langley Field of the NASA. The subject of Professor Cochkanoff's talk was "Manned Space Flight".

Professor Cochkanoff opened by observing that the problem with manned space flight was that of getting the man safely back to earth. There are three methods of so doing, namely, reverse firing rockets, gliding and high drag. The first is out of the question due to the weight of the fuel, the second will undoubtedly be the final solution but the third method is that which is being used in initial attempts.

The "Mercury" project and X-15 were then described in detail and the problems being faced and solutions proposed outlined, with particular emphasis on methods of preventing the vehicle from burning up and keeping the astronaut relatively cool.

At the conclusion of his talk, the speaker was thanked by Mr. Milman on behalf of those present.

Montreal

Reported by W. H. S. Bird
January Meeting

The regular monthly meeting was held at the Airlines Restaurant on January 19, 1960, Branch Chairman, Mr. R. F. O. Smith, presiding. 99 attended the dinner including 20 guests and 4 members of the Students' Section. 184 attended the lecture.

The speaker, Mr. R. P. Alex, introduced by Mr. J. Drummond, presented a most informative and interesting talk enlivened by many humorous anecdotes on his visit to Russia in connection with the FAI Conference in May and June 1959. Mr. Alex received the impression that living standards were definitely on the rise in Russia although in many aspects they had a long way to go to catch up to the American standards which the Russians apparently have set as a goal. Travel was not restricted and most of their questions were apparently freely answered.

He was informed that Aeroflot carried approximately 8,000,000 people in 1958 and by 1961 expect to carry 21,000,000 passengers. Aeroflot had 210,000 route miles and over 1,600 airplanes, mostly twin engine Il-14's. They were anticipating that AN-10 (4 turboprops, 100 passengers) would be adequate for use on sod fields and the Russians felt that these large turboprops had roughly the same speed and capacity as our present-day big jets but with greatly improved economy and flexibility. He was quite impressed with the TU-104A and Il-18 which were in the 70-80 passenger class with cruising speeds of about 500 mph.The Russians felt that the Americans and British have made a mistake by concentrating so much on pure jet for less than Mach 1 aircraft. Mr. Alex felt that the engine design and construction appeared to be excellent and that the aircraft design too was first rate.

The helicopters also appeared to be excellent although he had to take their word for many of their performance figures. He was impressed with the Mil-6 helicopter which has a gross weight of 75,000 lb, carried 80 passengers, and was anticipated for service use around mid-1960. There seemed to be free interchange of parts between designers i.e. Mil-4 uses a single 65 ft rotor with one 1750 hp piston engine (almost interchangeable with the Wright R1820) whereas the Yak-24 uses two of the same rotors and two of the same engines. Such procedures greatly speed up construction. Mr. Alex was able to fly a Mil-4 and also a Kamov-15 (co-axial rotors). He felt they were excellent examples of the helicopter art, although he was not impressed with the pilot of the Kamov-15 who demonstrated inverted flight, tight spirals and vertical stall maneuvers. Because of the lack of roads and the duration of train travel times, traffic between Moscow and various eastern cities is very heavy with load factors running close to 100%.

At the conclusion of Mr. Alex's talk, he was thanked by Mr. W. K. Ebel on behalf of those present.

Calgary

Reported by G. H. Ryning

January Meeting

Thirty-one members and guests attended the January dinner meeting of the Calgary Branch which was held in the Park Restaurant on Thursday, the 21st January. We were honoured by the attendance of guests Dr. D. C. MacPhail (President CAI), Mr. H. C. Luttman (Secretary CAI), Mr. R. McCallough, Manager, Calgary Division, Field Aviation, and guest speaker Mr. R. McCormach of Canadian Pratt & Whitney. Following the supper of steak, a brief business meeting was held to include announcements of the February meeting of the Branch and a reminder to all of the Mid-season Meeting to be held in Edmonton.

In a brief address, Dr. MacPhail spoke encouragingly of the present and future status of the CAI. Mr. Luttman also spoke briefly to the meeting, expressing his pleasure at the growth of the Calgary Branch and particularly of his being able to attend one of the Branch meetings. He also related that the Calgary Branch's status of being the junior Branch in the CAI, may soon be relinquished as there may soon be a new Branch forming at Quebec.

Following a recess, the guest speaker was introduced by Mr. G. H. Ryning. Mr. McCormach spoke on Pratt & Whitney's activities in the jet engine field in the past, present and future tense. The speaker then turned to the discussion form of presentation which met with good response from those gathered – particularly the aeronautics students present.

The guest speaker was thanked by Mr. G. H. Fenby of CPAL(R). Following this portion of the meeting, a business meeting was held between the Calgary Branch Executive and the CAI President and Secretary.

COMING EVENTS

CAI

24th and 25th May—*Annual General Meeting*, CHATEAU LAURIER, OTTAWA.

IAF

15th-20th August—*XIth International Astronautical Congress*, STOCKHOLM, SWEDEN.

ICAS

12th-16th September—*Second International Congress in the Aeronautical Sciences*, ZURICH, SWITZERLAND.

BRANCHES

Vancouver

30th April—*Annual General Meeting.*

Montreal

20th April—Visit to the new TCA overhaul base at Dorval. (Joint with SAE)

Halifax-Dartmouth

20th April – CPO's Mess, HMCS Shearwater, *Annual General Meeting.*

Winnipeg

12th April – Winnipeg Flying Club, *The Development of the Tyne Engine*, Speaker from Rolls-Royce, Derby.

10th May – Winnipeg Flying Club, *Truth Without Consequences*, Dr. P. J. Sandiford.

14th June – Winnipeg Flying Club, *Annual General Meeting.*

MEMBERS

NEWS

G. S. Glinski, A.F.C.A.I., has been elected a Fellow of the I.R.E.

D. H. E. Cross, M.C.A.I., has recently taken a position in the Directorate of Engineering Research, DRB, Ottawa.

M. C. Eames, M.C.A.I., has recently been appointed Chief Naval Architect at Cleveland Pneumatic Industries, Inc., Washington, D.C.

J. C. Howlett, M.C.A.I., has recently taken a position as Field Representative with the Boeing Airplane Co., Seattle.

G. C. V. Hurren, M.C.A.I., has been elected President of the Royal Canadian Flying Club Association.

Dr. P. A. Lapp, M.C.A.I., has been appointed Acting Chief Engineer of the Special Products Division of the De Havilland Aircraft of Canada Ltd.

R. B. Shannon, M.C.A.I., formerly with North American Aviation has recently taken a position as Senior Design Engineer in the Initial Project Office of Vertol Aircraft Corporation, Morton, Pennsylvania.

S/L K. F. Shepard, M.C.A.I., is at present attending the College of Aeronautics at Cranfield, England.

A. L. Bartlett, Technical Member, has taken a position with the Lincoln Laboratory of the Massachusetts Institute of Technology.

R. B. D. Wright, Technical Member, has taken a Senior Aeronautical Engineering position in the Jet Powerplant Group, Pan American World Airways.

ADMISSIONS

At a meeting of the Admissions Committee, the following was admitted to the grade shown, effective 4th January, 1960.

Associate Fellow

B. K. O. Lundberg, Director, The Aeronautical Research Institute of Sweden, Bromma, Sweden: *Box 1121, Bromma 11, Sweden.*

* * *

At a meeting of the Admission Committee, held on the 2nd February, 1960, the following were admitted to the grades shown.

Associate Fellow

I. M. Liss, Director of Engineering and Sales, Servomechanisms (Canada) Ltd.: *123 Rexdale Blvd., Rexdale, Toronto, Ont.*

Member

F/L G. R. Ayres, RCAF, Project Test Pilot, CEPE, Climatic Detachment, RCAF Stn. Namao, Alta.: *Box 11, Lancaster Park, Alta.*

S/L A. A. Chivers-Wilson, RCAF, Detachment Commander, 1205 TSU, Orenda Engines Ltd., Malton, Ont.: *24 Shirebrook Crescent, Brampton, Ont.*

F/O L. A. Flaherty, RCAF, Detachment Commander, 1003 TSD, Canadian Pacific Airlines (Repairs) Ltd., Lincoln Park, Alta.: *PMQ 151, RCAF Stn., Lincoln Park, Alta.*

J. M. MacTavish, General Manager, Fort Garry Tire & Auto Supplies, 208 Fort St., Winnipeg 1, Man.

Dr. R. F. Meyer, Assistant Research Officer, NAE Div., National Research Council, Ottawa, Ont.

S. C. Warren, Engineer A, Canadair Ltd., Montreal, P.Q.: *1465 Ouimet St., Apt. 16, St. Laurent, Montreal, P.Q.*

S/L A. J. S. Wright, RCAF Ret'd, Company Representative, Mount Royal Transportation Equipment Ltd., Montreal, P.Q.: *1715 Abbey Rd., Ottawa 1, Ont.*

Technical Member

Major E. P. Bishop, DADEME Vehicles & Aircraft, AHQ, Ottawa, Ont.: *1518 Kilborn Ave., Ottawa, Ont.*

L. M. Buckowski, Tooling Standards Technician, Trans-Canada Air Lines, Winnipeg, Man.: *424 Dalton St., Winnipeg 4, Man.*

H. G. Hughes, Quality Control Technician, Trans-Canada Air Lines, Winnipeg, Man.: *135 Bruce Ave., St. James, Man.*

LCDR. M. C. J. Major, RN Ret'd, Technical Writer, Canadair Ltd., Montreal, P.Q.: *440 62nd Ave., L'Abord-A-Plouffe, Montreal 9, P.Q.*

H. T. Redick, Production Engineer, De Havilland Aircraft of Canada Ltd., Downsview, Ont.: *55 Faywood Blvd., Apt. 305, Downsview, Ont.*

G. Singh, Aircraft Mechanic, Trans-Canada Air Lines, Vancouver, B.C.: *1025 Gilmore Crescent, Richmond, Vancouver, B.C.*

K. A. Toby, Mechanic, Trans-Canada Air Lines, Vancouver, B.C.: *3745 Dubois St., South Burnaby, B.C.*

W. R. Tucker, Supervisor, Railway & Power Engineering Corp., Winnipeg, Man.: *5130 Westhill Ave., Montreal, P.Q.*

E. G. Winnik, Engineering Planning Technician, Trans-Canada Air Lines, Winnipeg, Man.: *525 Enniskillen Ave., Winnipeg 4, Man.*

Student

W. S. Atkinson, Provincial Institute of Technology and Art, Calgary, Alta.: *827 - 19th Ave. S.W., Calgary, Alta.*

Officer Cadet T. M. Brett, Canadian Services College, Royal Roads, Victoria, B.C.

T. S. Brown, University of British Columbia, Vancouver, B.C.: *1190 E. 41st Ave., Vancouver 15, B.C.*

Officer Cadet F. M. Bucknum, Canadian Services College, Royal Roads, Victoria, B.C.

K. R. Cherniawsky, Provincial Institute of Technology and Art, Calgary, Alta.: *2012 17th Ave. N.W., Calgary, Alta.*

Officer Cadet R. M. Coatsworth, Canadian Services College, Royal Roads, Victoria, B.C.

D. M. Cowan, Ryerson Institute of Technology, Toronto, Ont.: *35 Withrow Ave., Toronto 6, Ont.*

D. N. Ferrence, University of Toronto, Toronto, Ont.: *Burwash Hall, 89 Charles St. W., Toronto 5, Ont.*

Flight Cadet D. L. Graham, Canadian Services College, Royal Roads, Victoria, B.C.

Officer Cadet J. M. Hannah, Canadian Services College, Royal Roads, Victoria, B.C.

P. H. Hinton, McGill University, Montreal, P.Q.: *3434 McTavish St., Montreal, P.Q.*

R. Knystautas, McGill University, Montreal, P.Q.: *35 Strathyre, Ville LaSalle, Montreal, P.Q.*

J. H. Lee, McGill University, Montreal, P.Q.: *Central YMCA, Room 439, 1441 Drummond, Montreal, P.Q.*

Flight Cadet J. A. Macdonald, Canadian Services College, Royal Roads, Victoria, B.C.

W. H. Mak, University of Toronto, Toronto, Ont.: *59 St. George St., Toronto 5, Ont.*

Officer Cadet K. D. McKay, Canadian Services College, Royal Roads, Victoria, B.C.

Officer Cadet D. S. Poole, Canadian Services College, Royal Roads, Victoria, B.C.

J. W. Quail, University of British Columbia, Vancouver, B.C.: *Acadia Camp, University of British Columbia, Vancouver, B.C.*

L. A. Roosdahl, University of British Columbia, Vancouver, B.C.: *Kootenay House, University of British Columbia, Vancouver, B.C.*

W. J. Scott, University of Toronto, Toronto, Ont.: *5 Devonshire Place, Toronto 5, Ont.*

Cadet L. E. Szentmiklossy, Canadian Services College, Royal Roads, Victoria, B.C.

B. R. Thomas, McGill University, Montreal, P.Q.: *5463 - 12th Ave., Montreal 36, P.Q.*

Naval Cadet B. M. Turner, Canadian Services College, Royal Roads, Victoria, B.C.

F/O J. A. F. Vieni, RCAF, McGill University, Montreal, P.Q.: *1555 Gravel Ave., Brossardville, P.Q.*

I. Wygnanski, McGill University, Montreal, P.Q.: *3833 Oxford Ave., Montreal, P.Q.*

Associate

R. R. Doyle, Assistant Personnel Manager, Rolls-Royce of Canada Ltd., Montreal, P.Q.: *4075 Namur St., Montreal, P.Q.*

J. A. McDonald, Superintendent of Stores, Pacific Western Airlines, Vancouver, B.C.: *Ste. 21, Pan American Apts., 10611 Kingsway, Edmonton, Alta.*

* * *

At a meeting of the Admissions Committee, held on the 10th February, 1960, the following were admitted to the grades shown.

Associate Fellow

Capt. (E) J. Doherty, RCN, Assistant Chief of Naval Technical Services (Air), RCNHQ, Ottawa, Ont.: *852 Byron Ave., Ottawa 3, Ont.*

L. Keast (on transfer from Member)

P. Martin, Head of Aerodynamic Test Group, Avro Aircraft Ltd., Malton, Ont.: *2058 Dickson Rd., Port Credit, Ont.*

Member

O. M. Cepella (on transfer from Technical Member)

S/L A. C. Drolet, RCAF, Aircraft Fluid Services Officer, RCAFHQ, Ottawa, Ont.: *1853 Russell Rd., Ottawa 1, Ont.*

F. Jackson, CARDE, Valcartier, P.Q.: *469 De Lavigerie, Ste-Foy, Quebec 10, P.Q.*

K. A. Kinsman (on transfer from Technical Member)

J. W. McNee, Regional Superintendent of Airports, Dept. of Transport, Edmonton, Alta.: *10159 - 119th St., Ste 6, Edmonton, Alta.*

A. Woeckner, Senior Engineer, Preliminary Design, Canadair Ltd., Montreal, P.Q.: *1651 - 5th Ave., St. Martin, P.Q.*

Technical Member

J. A. Watson, Engineer Mechanic, Okanagan Helicopters Ltd., Vancouver, B.C.: *7676 Angus Dr., Vancouver 14, B.C.*

Junior Member

J. W. Healey, Technical Statistician, Canadair Ltd., Montreal, P.Q.: *11950 Michel Sarrazin, Apt. 15, Montreal 9, P.Q.*

Student

R. J. Anderson, Provincial Institute of Technology and Art, Calgary, Alta.: *163 Malibou Rd., Calgary, Alta.*

L. E. Arnold, Provincial Institute of Technology and Art, Calgary, Alta.: *1004 - 19th Ave. N.W., Calgary, Alta.*

D. P. Arscott, McGill University, Montreal, P.Q.: *6037 - 30th Ave., Rosemount, Montreal, P.Q.*

R. A. Bowman, Provincial Institute of Technology and Art, Calgary, Alta.: *1612 - 2nd St. N.W., Calgary, Alta.*

G. W. Couser, Provincial Institute of Technology and Art, Calgary, Alta.: *91 Fairview Dr., Calgary, Alta.*

I. C. Cox, Provincial Institute of Technology and Art, Calgary, Alta.: *40-45th St. S.W., Calgary, Alta.*

J. P. Dueck, Provincial Institute of Technology and Art, Calgary, Alta.: *5335 Thornbriar Rd., Calgary, Alta.*

S. Goddard, Provincial Institute of Technology and Art, Calgary, Alta.: *816-16th S. N.W., Calgary, Alta.*

A. B. Halbert, Provincial Institute of Technology and Art, Calgary, Alta.: *440 - 14th St. N.W., Calgary, Alta.*

L. G. Kiehlbauch, Provincial Institute of Technology and Art, Calgary, Alta.: *619 - 27th Ave. N.W., Calgary, Alta.*

B. Kloosterman, Provincial Institute of Technology and Art, Calgary, Alta.: *1215 - 19th Ave. N.W., Calgary, Alta.*

R. J. Poitras, Provincial Institute of Technology and Art, Calgary, Alta.: *723 - 15th St. N.W., Calgary, Alta.*

E. F. Popek, Provincial Institute of Technology and Art, Calgary, Alta.: *2807 - 12th Ave. N.W., Calgary, Alta.*

W. H. Quakenbush, Provincial Institute of Technology and Art, Calgary, Alta.: *726 - 4th St. N.E., Calgary, Alta.*

O. H. Ratte, Provincial Institute of Technology and Art, Calgary, Alta.: *c/o Box 1156, Bowness, Alta.*

D. W. Rowley, Provincial Institute of Technology and Art, Calgary, Alta.: *257 - 22nd Ave. N.W., Calgary, Alta.*

L. B. Samoil, Provincial Institute of Technology and Art, Calgary, Alta.: *Two Hills, Alta.*

A. H. Smolkowski, Provincial Institute of Technology and Art, Calgary, Alta.: *345 - 19th Ave. S.W., Calgary, Alta.*

T. Terada, Provincial Institute of Technology and Art, Calgary, Alta.: *1501-18th Ave. N.W., Calgary, Alta.*

G. M. Thomson, Provincial Institute of Technology and Art, Calgary, Alta.: *1424 - 7 A St. N.W., Calgary, Alta.*

R. A. Wenig, Provincial Institute of Technology and Art, Calgary, Alta.: *113 - 12th St. N.W., Calgary, Alta.*

L. M. White, Provincial Institute of Technology and Art, Calgary, Alta.: *1423 - 20th St. N.W., Calgary, Alta.*

T. Yaremko, Provincial Institute of Technology and Art, Calgary, Alta.: *728-3rd Ave. N.W., Calgary, Alta.*

BOOKS

Medical Aspects of Flight Safety. Agardograph 30. Edited by E. Evrard, P. Bergeret and P. M. Van Wulfften Palthe. Pergamon Press, New York, 1959. 308 pages. Illus. $11.20.

Any new book which deals knowledgeably with problems of flight safety deserves a hearty welcome. Flight safety is a subject which is full of difficult questions and while this book answers few of the basic questions many of the papers in it are thought-provoking and offer fresh viewpoints.

Those whose important task it is to catalogue and abstract new publications must have difficulty in dealing with a book of this type. As a collection of some thirty papers, it is uneven in quality and does not cover the field comprehensively. As there is no index it is not easy to discover just what detail the book contains and what it does not. Furthermore, eight of the papers are in French, although English summaries are provided, as are summaries in French for the papers in English.

The papers which were presented at symposia in 1956 and 1957, are grouped into five chapters: Flight Safety and Aircraft Accidents, Unexplained Aircraft Accidents, The Use of Pathology in Crash Injuries, In-Flight Protection and a chapter of miscellaneous papers. As might be expected, such divisions are rather artificial and an examination of the text confirms this. From the book's title some discussion on the effects on flight safety of common ailments in aircrew might have been expected. While there are a number of important papers dealing with engineering problems bearing on safety, there is no adequate discussion, for example, of the special problems of underwater escape or of escape from two-place, multi-crew or passenger aircraft.

Many of the papers were written by recognized authorities, and are well worth study. However, practically all of the good, original material has appeared in scientific journals under other titles.

One important detail should be mentioned. A paper from the RAF describes a novel approach to Flight Safety through a newly-formed RAF Directorate of Flight Safety. The RCAF Directorate of this name has been in operation for nearly seven years, and its functions and method of operation follow closely those of the preceding Accident Investigation Branch, which was established during the last war. The RAF claim for a new approach, therefore, should not obscure this earlier establishment of a closely similar and successful RCAF agency.

The book is recommended for perusal, but the buyer should examine the contents before he parts with his money.

Dr. M. G. Whillans

High Temperature Materials. Edited by R. F. Hehemann and G. Mervin Ault. John Wiley & Sons, Inc., New York, 1959. 544 pages. Illus. $17.50.

This book is composed of the papers which were presented at the High Temperature Materials Conference held in Cleveland in April 1957. The Conference was sponsored by the High Temperature Alloys Committee, Institute of Metals Division, The Metallurgical Society, American Institute of Mining, Metallurgical and Petroleum Engineers. This rather lengthy title is that of only one organization.

There are over fifty authors who prepared the papers presented at this Conference. They emanate from universities, industry and US Government research establishments. Many may be considered as authorities in the field in which they write.

The book constitutes, what can be taken as, a summary of the status of knowledge and recent developments in the field of materials suitable for use at temperatures over 1500°F.

The papers are divided into seven groups, namely, cobalt- and nickel-base alloys, cermets and intermetallics, refractory metals, strengthening by dispersion of insoluble particles, vacuum melting and its effect on properties, effects of testing environment on properties and finally, oxidation resistance.

It will be obvious by this time, to even the most casual reader, that the subject matter of this book pertains directly to turbine engine design, although there are parts which would be useful in the field of high Mach number airframes, missiles and rockets.

Some of the papers are devoted almost exclusively to the subject of turbine engine buckets and discs. Many contain quantitative data on the properties of these high temperature materials, which information would be very difficult to find elsewhere in the literature, particularly since a number of these materials are proprietary in nature. Unfortunately, with the rapid progress being made in this field, a large amount of the data presented will be obsolete very soon, if not already so, especially since the Conference was held almost three years ago. It is a pity that it took so long for these papers to be put into print, so that everyone interested in the subject could have read them on a more timely basis!

Details of some of the subjects covered are: sintered aluminum and titanium products and why they behave as they do at high temperatures; high temperature failure mechanisms; high temperature properties of the refractory metals, chromium, molybdenum, tungsten, tantalum, columbium, rhenium; the superior properties possessed by metals which have been vacuum melted; and so forth.

For a volume of some 500 pages, it contains a wealth of information important to those in the turbine engine industry. This is considered to be so not only from the viewpoint of the reference data included but also from that of educational value which will help the reader to understand why certain phenomena occur and how they may be controlled to obtain useful materials.

Engine as well as some airframe and missile metallurgists will find this book to be very beneficial in their work.

J. J. Waller

Introduction to Rocket Technology. By V. I. Feodosiew and G. B. Siniarev, Academic Press, New York, 1959. 344 pages. Illus. $9.50.

The authors have made a purposeful presentation of the fundamentals of rocket technology in a form which does not demand too much specialized knowledge. In subject matter it is slightly more comprehensive than the 1949 edition of Rocket Propulsion Elements by G. P. Sutton and this new book appears to have been published in Russia during 1954. As far as additional technical data are concerned, the five year interval does not appear to have produced any interesting results—but the recent achievements of the Soviets speak for their competency in the fields described. As in Sutton's book, solid propellant rockets

are only briefly referred to but there is no reason to suppose that this implies neglect of this particular field.

Those buying this book will find that it principally covers rocket engine technology, aerodynamics of flight through the atmosphere, flight beyond the atmosphere and the principles of gyroscopic stabilization. These topics are all approached from a scientific rather than a descriptive engineering standpoint and consequently university students and others new to the field may find it a most readable primer. It can also be read with advantage by those who have written pseudo scientific books on rocket technology!

The translator, apologetically pandering to the Western technology, has laboriously converted all constants and equations from the cgs to the fps system and may have thus spoiled the book for many of its potential readers. Not having the original to study, it is not possible to decide whether the book was initially well referenced. The small list included at the tail end serves merely to indicate additional reading; another deficiency is the corresponding lack of information on the authors, which in view of the laudatory prologue about pioneer Russian rocketeers is surprising.

Summing up, it is a useful book presented in a logical scientific manner which contains no vital errors.

L. A. DICKINSON

Combustion and Propulsion — 3rd AGARD Colloquium. Edited by M. W. THRING, O. LUTZ, J. FABRI AND A. H. LEFEBVRE. Pergamon Press, New York, 1959. 614 pages. Illus. $20.00.

Engineers and researchers engaged on the aeronautical aspects of combustion will be familiar with the proceedings of the two earlier colloquia sponsored by the Combustion Panel of AGARD. (Cambridge 1953, Liege 1955.) Each of these volumes provided an invaluable international critical survey of the then current state of the combustion art with emphasis on the fundamental understanding of this very complex field. In 1956 the scope of the Combustion Panel was enlarged to include Propulsion and the Third Colloquium (Palermo 1958) included papers not only on combustion but on broader aspects of the rapidly extending and diversifying propulsion field. The present volume is organized into five main parts reflecting this extended scope, and is considerably more bulky than its predecessors. Part I deals with powerplant requirements as affected by aircraft mission, Part II with the interaction between combustion systems and engine components, Part III with propulsion system noise, Part IV with combustion in general and Part V with a miscellany of subjects, including high temperature shock waves, radiation heat transfer to hypersonic vehicles, and magneto hydrodynamics, under the group heading Aero Physical Chemistry. A concluding Part VI contains selected combustion papers from the 12th Technical Meeting of the AGARD Combustion and Propulsion Panel (Washington 1957). In all, twenty-one papers are included, 12 from the USA, 4 from France, 3 from the UK, and 2 from Germany. The French papers are presented in the original French, the rest in English. Each paper is concluded with a printed discussion of varying length together with the author's reply. As a possibly inevitable result of the broader scope, the present collection of papers forms a less well integrated whole than the previous volumes. The twenty-one papers represent a formidable array of basic information on a wide range of specific topics many of which are not closely related. He would be a rare reader indeed who could wade through the entire 600 pages with uniform interest and profit. However the same generally high standard of scholarship and attention to fundamentals which marked the earlier book seems to have been maintained and there is little doubt that, as a reference volume, the present text will find widespread use.

R. A. TYLER

Introduction to the Theory of Compressible Flow. By SHIH-I PAI, D. Van Nostrand Co. Inc., Toronto, 1959, 385 pages, Illus. $10.15.

In his preface, the author notes that the book is based on his lecture course in advanced aerodynamics at the University of Maryland. He points out that his aims in writing it are twofold: "This book is intended for students of fluid dynamics who are interested in the essential results and useful techniques in the theoretical analysis of compressible flow". The book is also to "serve as a useful reference to research workers in this field". The reviewer believes that the achievement of these aims is only partially successful.

The purpose of a book that is written as an introduction to a subject is to introduce and familiarize the reader with a field that is new to him. The present text, however, is written more in the form of a review for someone who is probably already quite familiar with the subject matter. Consequently, the reader who is seeking fundamental instruction will also have to go to other texts and reports to gain that knowledge.

The book consists of the following 17 chapters: Introduction; Thermodynamics and Physical Properties of Gases; One-Dimensional Flow of an Inviscid Compressible Fluid; Shock Waves; Fundamental Equations of the Aerodynamics of a Compressible, Inviscid and Nonheat Conducting Fluid; Method of Small Perturbations, Linearized Theory; Two-Dimensional Subsonic Steady Potential Flow; Hodograph Method; Exact Solutions of Two-Dimensional Isentropic Steady Flow Equations; Two-Dimensional Steady Transonic and Hypersonic Flows; Method of Characteristics; Linearized Theory of Three-Dimensional Potential Flow; Nonlinear Theory of Three-Dimensional Compressible Flow; Anisentropic (Rotational) Flow of Inviscid Compressible Fluid; Flow of Viscous Compressible Fluids and of Mixtures of Gases; Boundary-Layer Flow of Viscous Compressible Fluids; Magnetogasdynamics. Each chapter is followed by a reasonable number of problems and useful references.

A number of misprints and undefined terms occur in the text. The lack of illustrations concerning many flow problems is also quite apparent.

Of the 17 chapters noted above one of the least rewarding is the one concerned with Thermodynamics and Physical Properties of Gases, and those sections dealing with imperfect gas flows. The last three chapters are topical and interesting. However, owing to brevity and an absence of the development of fundamental concepts (for example, the section on diffusion and chemical reactions and the chapter on Magnetogasdynamics) the reader will have to supplement this information from other sources.

This text will probably be more useful to the research worker. The student will do better with one of the several existing good books in gasdynamics despite their omission of such timely topics as flows with chemical reactions and magnetogasdynamic effects.

DR. I. I. GLASS

SUSTAINING MEMBERS

of the

CANADIAN AERONAUTICAL INSTITUTE

1959-60

Aeroquip (Canada) Limited

Aircraft Industries of Canada Limited

Alloy Metal Sales Limited

Aviation Electric Limited

Avro Aircraft Limited

Bristol Aero-Industries Limited

Canadair Limited

Canadian Flight Equipment Cobourg Ltd.

Canadian Pacific Air Lines Limited

Canadian Pratt & Whitney Aircraft Company Limited

Canadian Steel Improvement Limited

Canadian Westinghouse Company Limited

Cannon Electric Canada Limited

Carriere and MacFeeters Limited

Collins Radio Company of Canada Limited

Computing Devices of Canada Limited

Consolidated Diesel Electric Corporation of Canada Limited

DeHavilland Aircraft of Canada Limited

D. Napier & Son (Canada) Limited

Dowty Equipment of Canada Limited

Enamel & Heating Products Limited

Fairey Aviation Company of Canada Limited

Field Aviation Company Limited

Garrett Manufacturing Limited

General Controls Co. (Canadian) Limited

Godfrey Engineering Company Limited

Goodyear Tire & Rubber Company of Canada Limited

Honeywell Controls Limited

Imperial Oil Limited

Jarry Hydraulics Limited

Lucas-Rotax Limited

Moffats Limited (Avco of Canada)

Normalair (Canada) Limited

Northwest Industries Limited

Okanagan Helicopters Limited

Orenda Engines Limited

Prenco Progress & Engineering Corporation Limited

Railway & Power Engineering Corporation Limited

Rolls-Royce of Canada Limited

Rousseau Controls Limited

Shell Oil Company of Canada Limited

Simmonds Aerocessories of Canada Limited

S. Smith & Sons (Canada) Limited

Spartan Air Services Limited

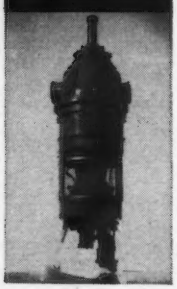
Standard Aero Engine Limited

Trans-Canada Air Lines

Walter Kidde & Company Limited

York Gears Limited

PT-6



turboprop

Versatile New Engine
by CANADIAN PRATT & WHITNEY

Canada's first turboprop is a radical departure in engine design. The PT6 is an axial-centrifugal flow, moderate pressure ratio turbine engine with a free turbine drive for either turboprop or turboshaft installations. This 500 h.p. power plant is ideally suited for single or multi-engine fixed wing aircraft, helicopters or high speed marine installations. From a functional point of view, it weighs just 250 pounds, yet combines rugged service and dependable performance with the practical economies of low fuel consumption and ease of maintenance.

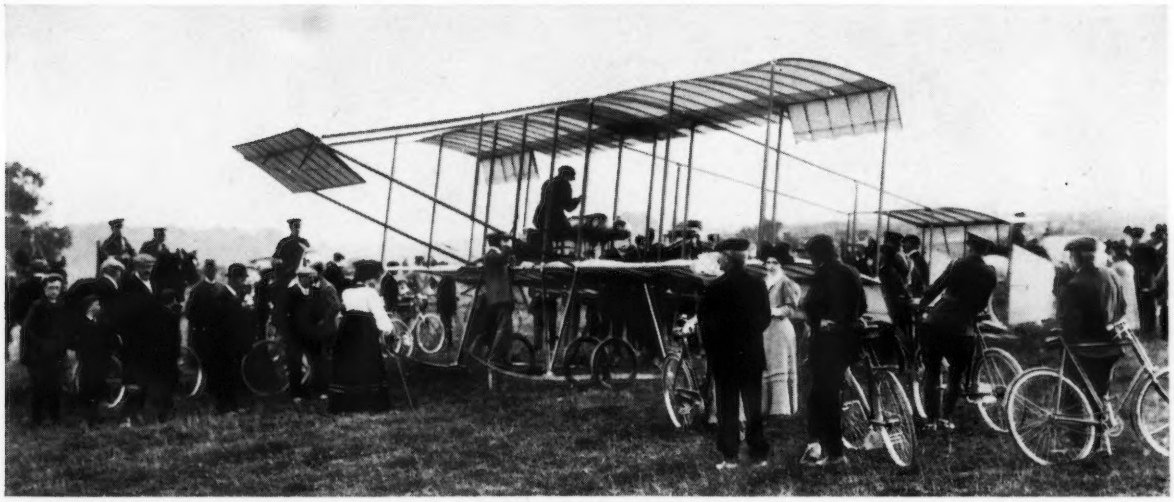
Applications from Experienced and Qualified Engineers Are Invited.

Available in 1961 from:

Canadian Pratt & Whitney Aircraft

COMPANY, LIMITED Longueuil, Montreal, P.Q.

PRATT & WHITNEY ENGINES • SIKORSKY HELICOPTERS • HAMILTON STANDARD PRODUCTS • NORDEN ELECTRONICS



FROM "BOXKITE" TO "BRITANNIA"!

BRISTOL

50 years serving Commonwealth Air Forces
A decade serving the industry as a wholly Canadian Company

BRISTOL AERO-INDUSTRIES LIMITED
MONTREAL TORONTO WINNIPEG VANCOUVER